The Collection Of

Specimens Of Urine From Infants,

With

Observations On Renal Function

In The First Two Weeks Of Life.

A Thesis

Presented For The Degree Of

Doctor Of Medicine.

By

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PREFACE.

It is difficult to find a short but comprehensive title for this thesis. For this reason the liberty is taken of giving a fuller description of it's scope in this preface.

The thesis is divided into three parts and an appendix. Part one is devoted to methods of collecting specimens of urine. Part two is divided into four sections, the first of which offers some evidence of the clinical state of the 63 infants with whom this thesis is mainly concerned. The remaining three sections deal with the establishment of post-natal renal function, the volume of the urinary output, and the frequency of micturition. Part three is devoted to a short consideration of the specific gravity, and the hydrogen ion concentration of the urine, as well as it's urea and chloride content.

In the appendix will be found the data concerning the urine which has been collected.

It remains for me to state that, including all sketches, photographic enlargements and graphs, this thesis is my own work.

P A R T . I .

METHODS OF COLLECTING URINE FROM INFANTS.

C O N T E N T S .

Section. III. An electrical device to signal when urine is passed.

Section. IV. Apparatus intended for signalling when a baby passes urine.
- An Historical Survey. -

S E C T I O N . 1.

H I S T O R I C A L .

INTRODUCTION.

Our knowledge of renal function in the newly born infant is scanty. This is due to several diff-:iculties. The small quantity of urine passed at one voiding is one of the greatest of these diffi-:culties. It is for this reason that one cannot very readily make more than a few chemical or physical observations on such a specimen of urine. Another difficulty arises in deciding how the specimen of urine is to be collected. The technique employed must be reasonably dependable, for one must be care-:full to avoid any loss of urine. While the collection of single specimens of urine is helpfull, it is essent-:ial to attempt to collect 24 hour specimens. While this is considered to be difficult to do, the contin-:ual collection of urine from the same infant for several consecutive days is admitted by all to be no mean accomplishment. It is obvious that some sort of apparatus by way of a urinal is essential, and it is of no little interest to examine such literature as is available on this subject, that one may learn what human ingenuity, originality, and resourcefulness may have devised for the purpose.

SURVEY /

SURVEY OF THE LITERATURE.

1839. The earliest writers on the urine in the new born are Huenefeld (1839) and Rayer (1839), the latter quoted by Cruse (1877). Neither, however, discloses how the urine was collected.

1855. Hodann (1855) is quoted by Martin and Ruge (1876), Cruse (1877) and Reusing (1895) as having recorded observations on the urine in the newly born. He did not, however, collect urine but relied largely on the naked eye description of the wet napkin. He seems to have been especially interested in uric acid crystals, uric acid infarcts and medical jurisprudence.

1856. Picard (1856) quoted by Cruse (1877) does not disclose how the few specimens, analysis of which he publishes, were obtained.

1857. In this year there is recorded by Hecker (1857) one or two observations on the urine in the newly born. He collected the urine from the 3rd. day to the 8th. day, and on this composite sample conducted an analysis, of which this is part of his result:- Volume 375 cc. Specific gravity 1001. Urea 450 mgm.%. Chlorides 150 mgm.%. On a further composite specimen up to the 17th day he made another analysis but he also states "the specimen was much contaminated - sehr unrein - with hair, epithelium and colouring matter, etc." Obviously he was in difficulty over the collection /

collection of his specimen, and possibly over its subsequent preservation as well. His method was primitive, simply to hold the infant over a receptacle at and after feeding time and hope for the best.

Bouchaud (1864) used a rubber balloon with a circular opening to admit the scrotum and penis to the inside of it. Inside this balloon he first put absorbent gauze to take up the urine which, otherwise, he
1864. found percolated through the rubber and was lost. He found the weight of urine by weighing beforehand the balloon with gauze dry and afterwards weighing it when the infant had passed urine. His analyses are, for obvious reasons, unreliable.

Professor Dohrn of Marburg (1867) examined the urine in the first day of life, but obtained his specimens simply by passing a catheter. This
1867. procedure is certainly simple and easy, but fraught with great risk and is certainly not one to be often repeated or undertaken lightly. He determined in this way the volume of urine in the bladder at birth, examining in all 75 infants.

Otto Pollak of Vienna (1869), in his study of the urine, showed a great understanding of the difficulties
1869. of the problem, and his remarks stand as an object lesson to later investigators. They would have, I feel /

feel sure, prevented Gerstenberger (1909) from suggesting and making his apparatus, had he been able to read them some forty years after they were published.

Pollak (1869) tried at first to collect the urine by laying the infant upon a sheet of oil-cloth. From this he made three observations.

(1) The infant was uncomfortable.

(2) The urine was contaminated by faeces and vice versa.

(3) Owing to the urine, once it was passed, being spread over a large area, considerable evaporation took place so that the specific gravity was found to be higher than it should be.

He, therefore, used for boys a small glass bottle with a narrow neck to accommodate the penis. This, he says, was bound over the buttocks. There is no other description of the bottle given except that it was small and made of glass.

For girls he found it very difficult to collect even a small quantity of urine, and so he had made for the purpose "catheters of the thickness of an exploring cannula."

Quinquaud (1872) in his observations on urea in
1872. newly born infants given in his thesis used the same method /

method as Pollak (1869) for the collection of his specimens.

In this year Harley (1875) published some work on the urine but he does not disclose how he obtained
1875. his specimens. Neither for that matter do Martin and Ruge and Biedermann (1875) in their work, published in the same year. In the following year, however,
1876. Martin and Ruge, in an article which is much quoted, describe how, in their studies, they attempted in the first instance to form a urinal or bladder out of gold-beater's skin. Within this bladder they enclosed the penis and scrotum, holding the bladder in position by means of a rubber ring which encircled the whole of the external genitalia. The gold-beater's skin they did not find very successful and substituted for it a rubber balloon or bladder fastened on apparently in the same manner. With this apparatus they made some reasonably accurate observations on the 24-hour renal output in the first day or two of life.

Parrot and Robin (1876) do not disclose their method but, with their paper as with that of Martin
1876. and Ruge just referred to, it would appear that we may now be entering upon work of a somewhat more reliable nature. They give no analyses of 24-hour urine and appear to have obtained part specimens only.

Camerer /

Camerer (1876) adopted an even more complicated and unwieldy method than Bouchaud (1864) for, in addition to carrying out the latter's procedure, he swathed the infant in as many flannels as he thought would be necessary to absorb any urine which might escape. Here are his words - "Das kind wird in Leinwandwindeln, Kautschuk und wollene Decken derart
1876. eingewickelt, dass eine Verdunstenig des Wassers der Ausleerungen unmöglich ist." The weight of all this dry clothing was recorded. Later when urine had been passed and perhaps the bowels had moved as well, he weighed the whole of this clothing to find how much it had gained in weight. He then endeavoured to weigh the faeces and by subtraction to arrive at the weight of the lost urine. This procedure was carried out 4-hourly by day, with a long interval of 10 hours by night. The only importance which can be attached to his work is that it shows how unreliable Bouchaud's method must have been.

Cruse (1877), working in Die Findelhause, St. Petersburg, is the next writer on the subject. He states that he devoted a whole year towards endeavouring to make a suitable urinal of black rubber in the doing of which he made use of - "benutzte" - the
1877. customary receptacle - "gebrauchlichen Recipienten" - used in cases of incontinence. He says that he was no /

no more successful than Hecker (1857) was, because, though his apparatus worked perfectly - "vollkommenste" - it had the great disadvantage that he had to wait a long time for an infant which would fit it. His apparatus appears to have been a rubber bag of sorts with a hole in it for the insertion of penis and scrotum. He says (1) either the penis and scrotum were so big that they could not be got through the hole; (2) or the distance from scrotum to anus was so little that the receptacle was contaminated with faeces; (3) or the skin was so tender that the rigid pressure of the abdominal and thigh straps, used to fasten it on with, caused ulcerations and even, he says, gangrene of the skin. So he gave up the use of his apparatus of which he gives no clearer description than can be gathered from the foregoing.

He then tried out Bouchaud's method, using sticking plaster to fasten the rubber balloon on with. Despite this reinforcement, he says, it was unsatisfactory. Next he thought to use Martin and Ruge's method but found the cost of the rubber balloons a hindrance.

He then tried the use of condoms, pointing out that they are very thin like paper and not likely to do any damage. They enclose penis and scrotum, and are fastened on at the inlet by a rubber ring after the manner of Martin and Ruge. They cannot be used unless /

unless the scrotum is well developed. When the rubber ring was too tight he observed oedema of the penis and excoriation of the skin. In such cases he removed his apparatus from the infant. He appears to have been fairly successful with his method and to have had very reliable nurses working for him. For other reasons, which I will give later, his work is, however, of little value in a study of the urine in the normal new born.

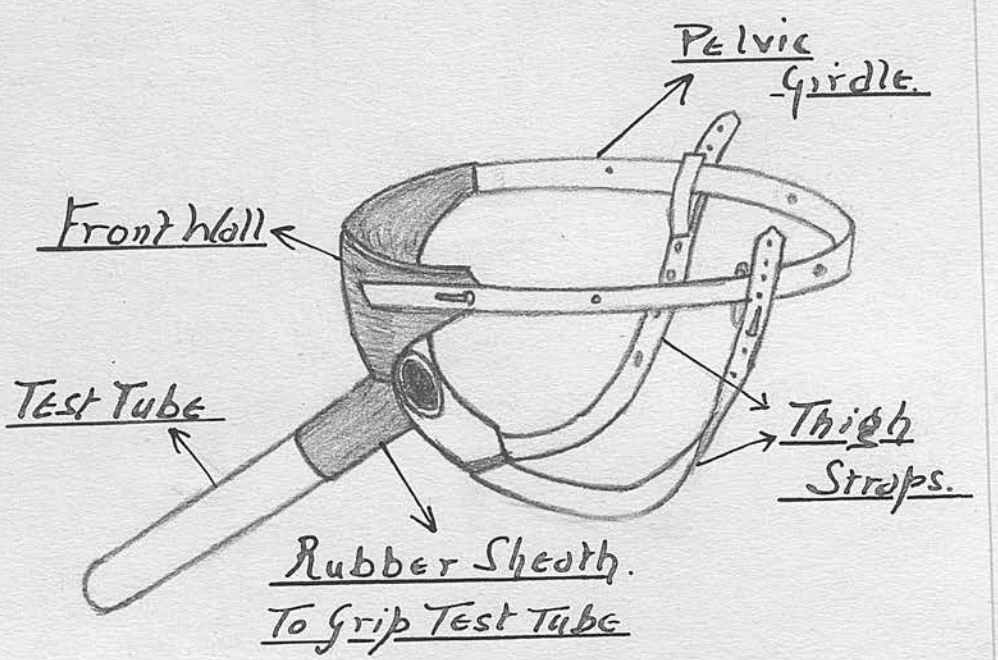
1879. A much quoted work was published in this year by Anna Schabanova (1879). Ballantyne (1891) quotes it. Examination of the publication shows, however, that in actual fact she did no work whatever on this subject, but merely refers to work already done by some of the aforementioned workers.

R. W. Raudnitz /

After.

Roudnitz. R. W.

Prague.



manufacturer. Waldeck u. Wagner.

Prague.

R. W. Raudnitz of Prague (1883) advocated the use of test-tubes for the collection of urine from male infants. For the fastening of them on, he
1883. advocated the use of his special harness, a sketch drawing of which is given. The pelvic girdle and thigh straps are of red rubber while the front wall and sheath for test-tubes are of a more elastic rubber - "aus reinem gummi."

Adolf Baginsky /

Adolf Baginsky (1888) does not tell us how he
1888. obtained the few specimens of urine which he refers to in his paper on acetonuria.

Ernest Schiff (1893) describes an apparatus which he saw in use during a visit to the Foundling house in Prague. It appears to have been constructed according to Professor Epstein's instructions. In plain language it was an apparatus for male infants, using a small bottle over the mouth of which he drew a
1893 - rubber teat. The end of the teat was then cut to
1895. permit the entry of the penis. The special apparatus was made by Waldeck and Wagner of Prague for the price of 1 florin 50 kroner.

Schiff worked with this apparatus but found it unreliable, an observation which was confirmed by Lange (1895) who also tried to use it. The latter states a restless child could loosen the bandages and the urine would be lost; while in other cases maceration of the skin would appear, demanding the removal of the apparatus and the cessation of the experiment. In some instances he found his
1893 - collection of urine was so small compared with the
1895. child's intake that he looked upon the method as being quite unreliable. For example, on an intake of 760 cc. he only got 137.5 cc. of urine, and in another /

another instance on an intake of 850 cc. he only collected 155 cc. of urine.

Rudel's (1894) description of the method he used to collect urine in his investigations into rickets is meagre. "At a year old the urine was caught in a rubber bottle which was fastened to the abdomen with sticking plaster. The bottle had a hole in it through which the penis and scrotum were inserted." Thus, beyond knowing the basic principle upon which he worked, we have no other information.

1894.

Reusing (1895), in his work, condemns the use of balloons, rubber bags, condoms and gold-beater's skin, saying (1) he was not certain of his results - "war ich nicht sicher," (2) They were often unusable because of lack of development of the scrotum. (3) They caused pressure sores and oedema of the penis. He goes on to say "After long experimenting I hit upon a method" which, he rather naively affirms, is "as sure as it is comfortable" - "eben so sicher als bequem" He had the infant put in a half upright position and placed an adult bed urinal between the legs, so that penis and scrotum were inside the entrance to the urinal.

1895.

Rey (1895) used a rubber bag fastened over the external genitals. It is interesting in passing to note that one of his subjects was a girl of apparently

1895.

2½ /

2½ years who was so intelligent that she was able to co-operate in the experiment and pass urine and faeces separately when required. "Das eine der Versuchs kinder war ein mädchen: dasselbe war indess fur sein Alter sehr intelligent und willenskraftig und erleerte Urine und Stuhl in genauester Weisse getrennt."

Michel and Budin (1897) and Michel (1896) in their work used condoms. Umikoff of St. Petersburg (1897) gives no indication of how he obtained the specimens of urine from infants of 4 days to 5 months old for his diadzo reaction experiments.

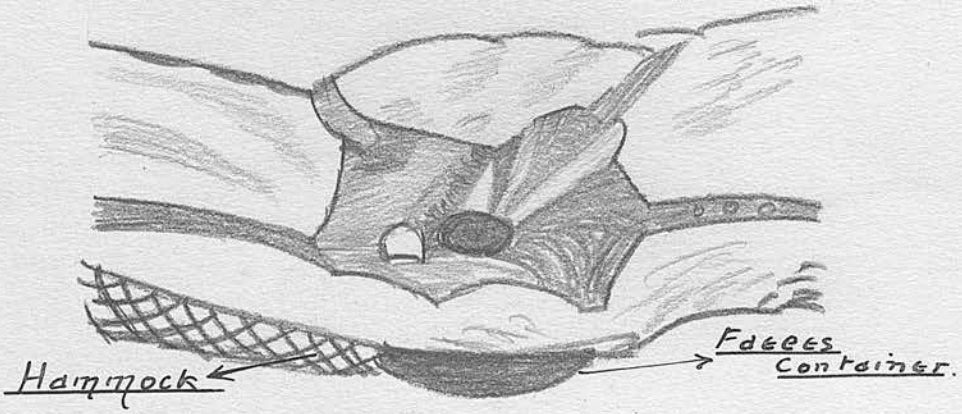
1896 - 1897.

At about this time investigators began to be interested in the faeces of infants as well as in the urine and so we enter upon a new era in the construction of urinals. We are introduced to the idea of the metabolism bed by Heubner at a meeting of the Berlin Medical Society held on the 13th February, 1895. On that occasion it would appear that Heubner was deputising for Professor Krauts of Munich. He demonstrates Krauts's apparatus which is called a "Trockenbett" - dry bed - in the text of the article, and a "Lagerungsapparates" - recumbent apparatus - in the title. This apparatus was a bed of sorts upon which a small infant could be placed and kept in one position by means of restraining bandages, rubber bands and a small corset. It was intended apparently for use in the /

the treatment of intertrigo, furunculosis and, I think, perhaps eczema, though on this latter point the text is not clear to me. At all events the idea was to use this apparatus in the nursing of infants where restraint and prevention of movement was considered to be of vital importance. Most especially was it meant, as we can gather from the title of the publication - "Demonstration eines Lagerungsapparates für kleine Kinder zur Verhütung von Durchnassung" - to be used with a view to the prevention of the soiling and soaking of the buttocks and adjoining parts, with urine and faeces. Hence the name "Trockenbett." Heubner observes that some such similar type of apparatus might be evolved to embody the features of separate collection of urine and faeces. This, he says, would open the way to a study of metabolism in small children. His suggestion seems to have been seized upon by Bendix (1896) who, working in Heubner's Clinic in Berlin in the following year, constructed the first piece of apparatus of this kind. Put briefly, it was a sort of hammock - Hängematte - with an opening for the /

After

Bernhard Bendix.



Sketchs to give some idea of the First Metabolism Bed for Infants

the buttocks beneath which was placed a receptacle to catch the faeces. The urinal consisted of a strong condom 10 cm. long x 5 cm. broad fastened over the penis and scrotum and held on by means of two thigh straps and one abdominal strap fastened in turn to a belt placed over the infant's jacket - Kinderjäckchen.- From the condom a tube lead to a receptacle in which the urine was collected. This is the first instance of the urine being collected at a distance from the child. Attention was paid to the position of the infant, the level of the feet being made lower than that of the head so as to encourage the urine to flow once it had been passed. This was not difficult since the infant was fixed on the hammock so that it could not move much.

Lange, J., of Leipzig, and Berend, N. of Budapest (1897), working in the Leipzig Clinic, constructed an apparatus similar to that of Bendix. With it, they had the same experience as Reubner and Heubner mentioned below; namely, the occurrence of diarrhoea.

1897.

Reubner and Heubner (1898-1899) worked with Bendix's apparatus and they observed that infants placed upon it tended to develop diarrhoea. There is some doubt as to whether it can have been of an infective origin since the diarrhoea ceased almost at once if the infant were removed from the apparatus.

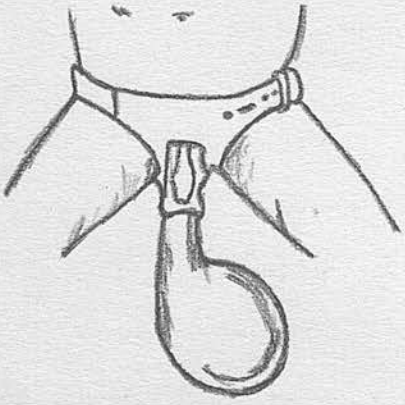
1898 - 1899.

Keller, A., (1898),in the Breslau Clinic, constructed /

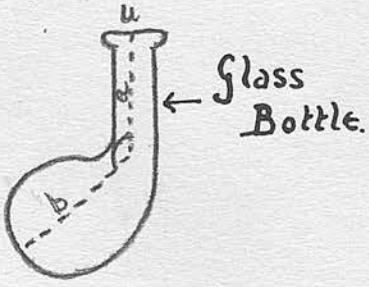
After

Freund: W.

Breslau.



Showing Method of fixing bottle on.



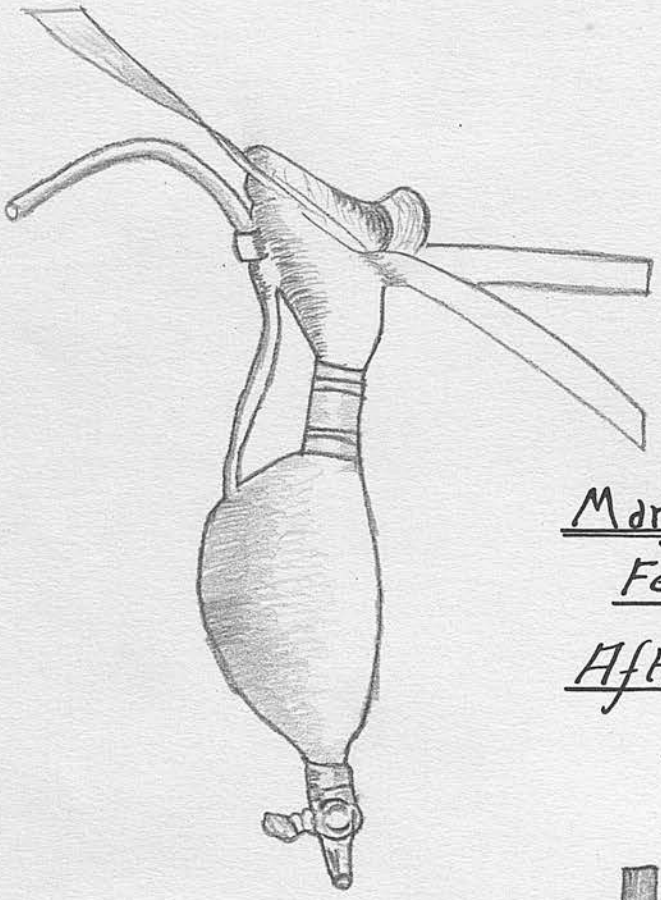
a. 8 cm.
b. 10 cm.
u. 2·5 cm.
∠ 135°

Showing Method of Fixing Infant in Cot.

1898. constructed such a piece of apparatus somewhat after the style of Lange and with its use he also observed the occurrence of diarrhoea.

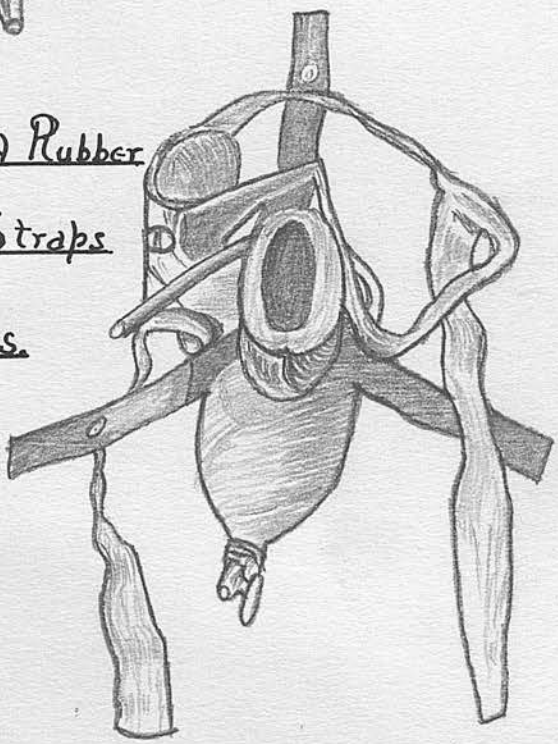
Freund, W., of Breslau (1898), suggested that the cause of the diarrhoea was the exposure of the infant's buttocks which the use of this type of apparatus necessitated. He, with Keller, devised another technique which avoided this. For a urinal they followed the directions of Raudnitz in the use of a test tube but soon abandoned this for a small glass flask having a neck set at an angle of 135°. The bottle, placed between the thighs, was held in position by a pelvic girdle and thigh strap similar to that of Raudnitz.

Marfan (1897) in this year described an apparatus suitable for the collection of urine in boys and, with
1897. slight modification, in girls also. "The urinal for boys is made of red rubber and has the shape from before backwards of a flattened pear 25 cm. long and 10 cm. broad. It is closed at the lower end by a stopcock. In the posterior wall in the midline somewhat above the centre there is a round hole 1½ cm. in diameter. Through this hole the penis and scrotum were placed. To avoid pressure upon the genitals two adjoining hollows are formed, one for the penis and one for the scrotum." Just exactly what this means is /



Marfan's
Female Urinal
After
Blacher.

Material
Semi-Vulcanised Rubber
Linen Girdle & Straps
Rubber Straps.



is not clear and there is no diagram given. "The apparatus is fixed by a belt or girdle, to which go two thigh straps from the posterior wall of the apparatus at the lower border of the hole."

"The urinal for girls is 25 cm. long and made up of a funnel and a pear joined to each other by a narrow neck. The funnel is flattened sideways and has an opening 6 cm. long and 2 cm. broad and covers the whole of the vulva. The pear is closed below by a stopcock. The whole apparatus is fastened on by 2 abdominal and 2 thigh straps made of rubber."

This is the first attempt to collect urine from a girl.

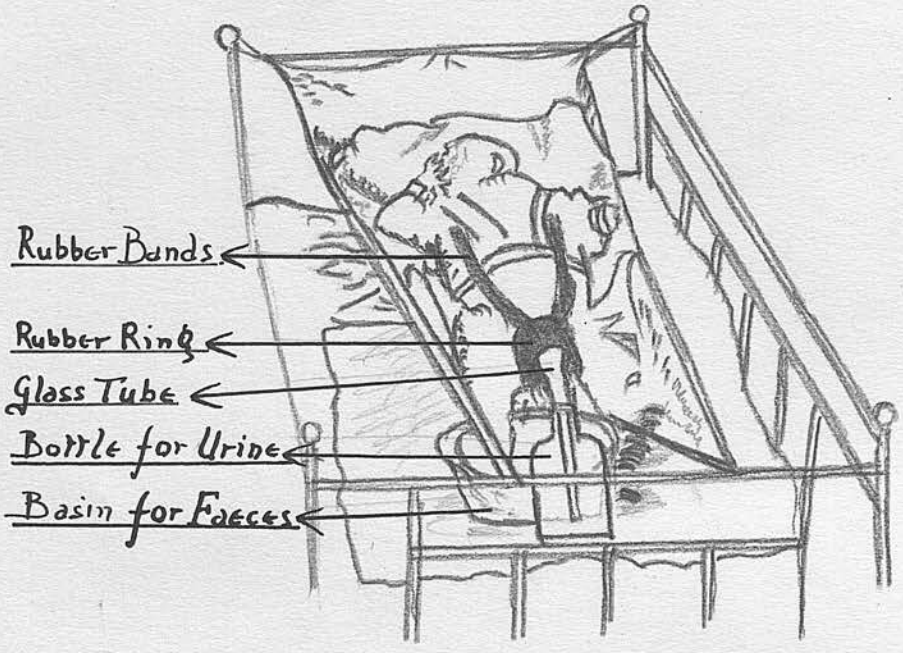
This apparatus of Marfan's as used for boys was
1900. "modified" by Professor Gundobin, St. Petersburg, and is described by Blacher (1900). Endeavours to have this modified apparatus made in the local rubber factory in St. Petersburg failed. As Gundobin says, there being no money in it, the manufacturer was not interested. This apparatus was used by Kotscharowsky (1899), Hein (1904) and Gundobin (1906).

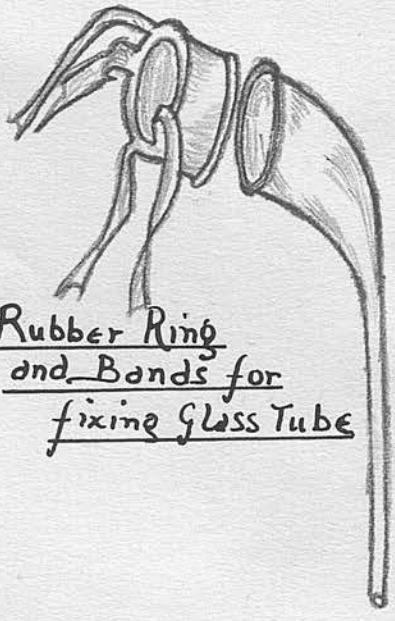
Bendix /

After.

Bendix. B and Finkelstein. H.

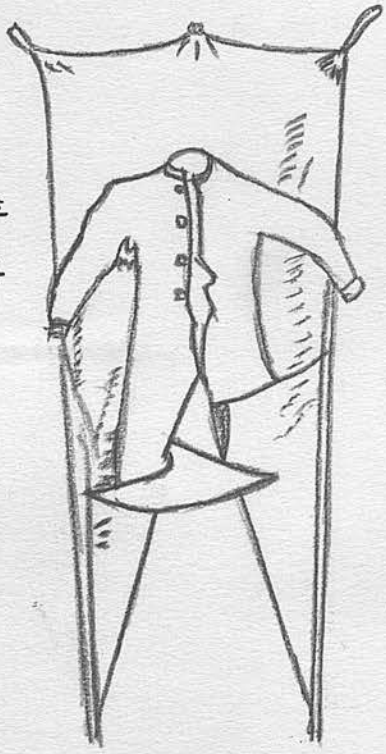
Berlin.





Rubber Ring and Bands for fixing Glass Tube

Glass Tube to contain Penis.

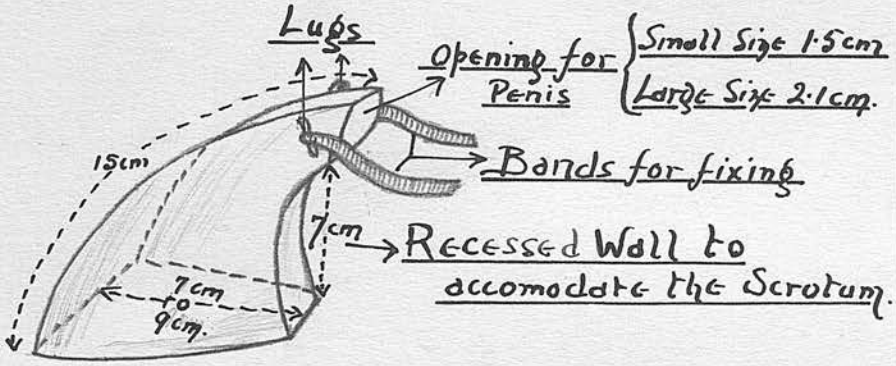


1900. Bendix and Finkelstein (1900) made suggestions for a technique suitable for metabolism experiments in infants. The sketch shows the method they adopted for the collection of the urine. It was used by Cronheim and Müller (1902-1903; 1908) in their studies.

After

Ernst. Teuffel

Dresden



Capacity. Small Size 160cc.
Large Size 200cc.

Manufacturer Carl Wiegand.
Dresden. N.

Price M.—.70.

1907. Teuffel, E. (1907) of Dresden, had constructed a urinal made of glass and of somewhat unique shape which is best described by reference to the accompany--ing sketch. It is intended for male infants only. Placed between the thighs, it was tied on by two bands. He ends his short paper by saying "I hope soon to be able to demonstrate a suitable glass for female infants." - Ein entsprechendes Glass für den Weiblichen Säugling hoffe ich bald demonstrieren zu können." So far as I have been able to discover, this hope has not been fulfilled.

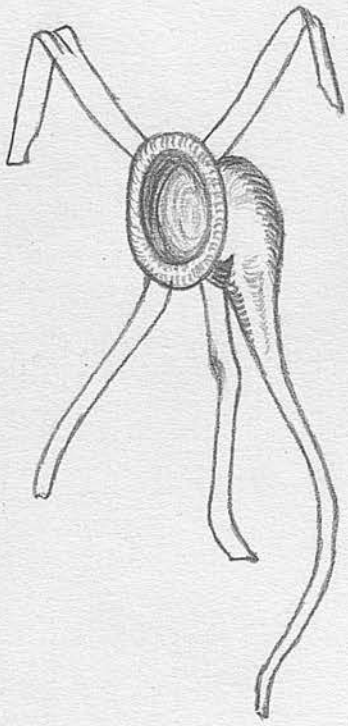


Fig. No. 1.

Urinal and Straps entirely made of Rubber

Note. The wide soft rim.

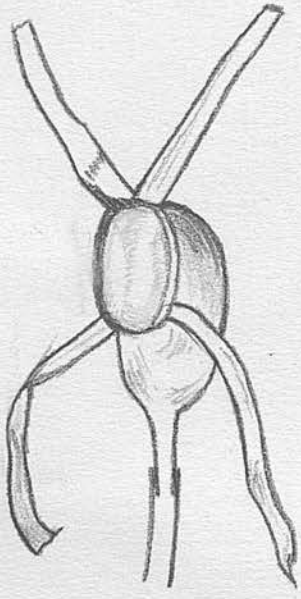


Fig No. 2.

Glass Urinal with Linen Straps for fixing

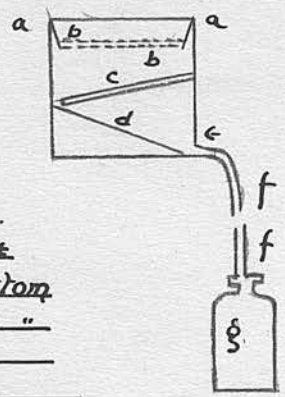
After Schabad. J. A.
Klinik für Kinderkrankheiten.
St. Petersburg.

1908.

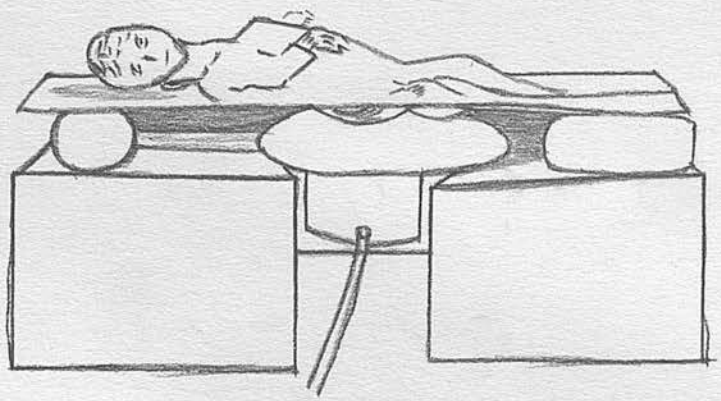
In the following year Schabad of St. Petersburg (1908) constructed an apparatus of which a sketch drawing is given. In addition to fastening it on by the straps to a belt he fixed it round the edges to the skin with sticking plaster. It is part of his technique for the collection of both urine and faeces, and he states "with the aid of this apparatus I have up till now been completely successful in 25 experiments; 1 of 1 day's duration; 8 of 3 days; 1 of 5 days; 4 of 12 days and 1 of 14 days." He did not, however, work with new born infants.

After.

Gerstenberger. H. J

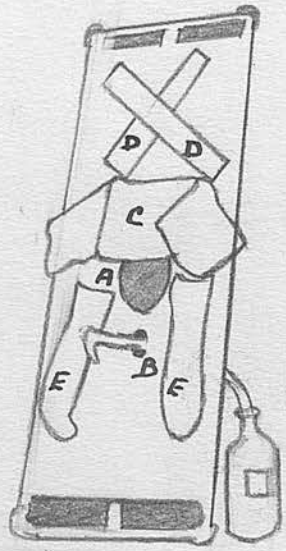


a.a Outside Can.
b.b Double Sieve
c. 1st False Bottom
d. 2nd " " " . . "
e. Spout.
f.f. Tubing
g. Receiving Bottle.



1909.

Gerstenberger (1909) in this year contrived an apparatus for the collection of faeces and urine from infant girls. Consideration of the sketch given will show that it certainly could do this but that it would hardly be suitable for young infants. Moreover, its scientific value must be, indeed, small. No attempt is made to avoid contamination of the urine by faeces; indeed, contamination is invited, while the metal construction would surely lead to chemical action with the urine.



After Talbot. F. B.
Boston. U. S. A.

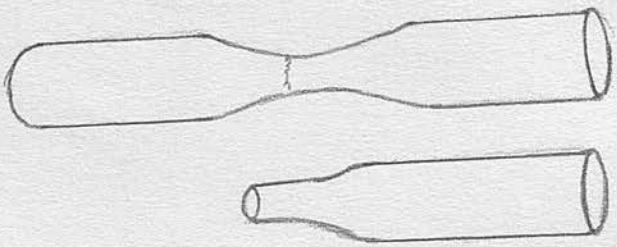
A. Hole over which buttocks come.

B. Small hole through which tube leading from penis is passed.

C. Towel fastened to Bradford Frame and which confines the infant's trunk.

D. Two cloth straps to be pinned across the shoulders.

E. Stockings fixed to frame and which confine the legs.



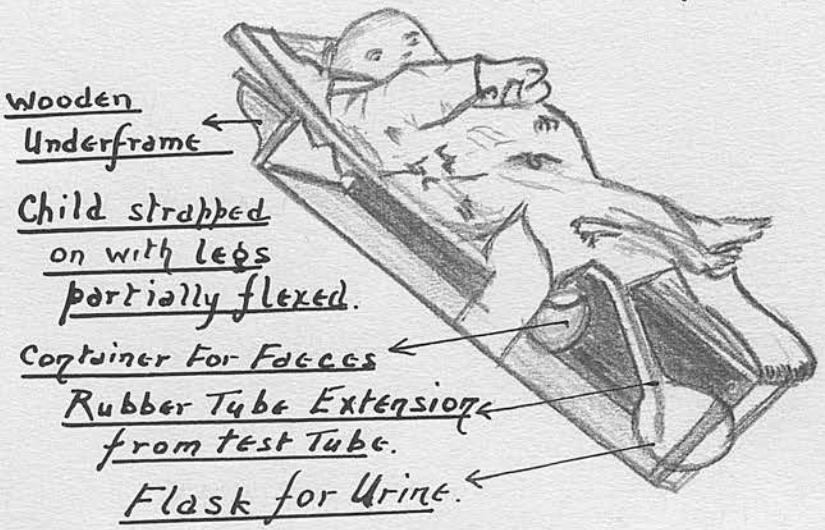
Showing method of drawing out heated test tube so as to encase the penis.

1909. In the same year as Gerstenberger described his apparatus, F.B. Talbot of Boston (1909), who has carried out so much work on metabolism in infants, described his metabolism frame, the foundation of which is a Bradford frame. His urinal works on the test tube principle with a distantly placed collecting vessel to which the modified test tube is connected. The infant is strapped down upon the frame, thus making the method rather unsuitable for new born infants. Moreover it is only applicable to male infants..

After

Du Bois.

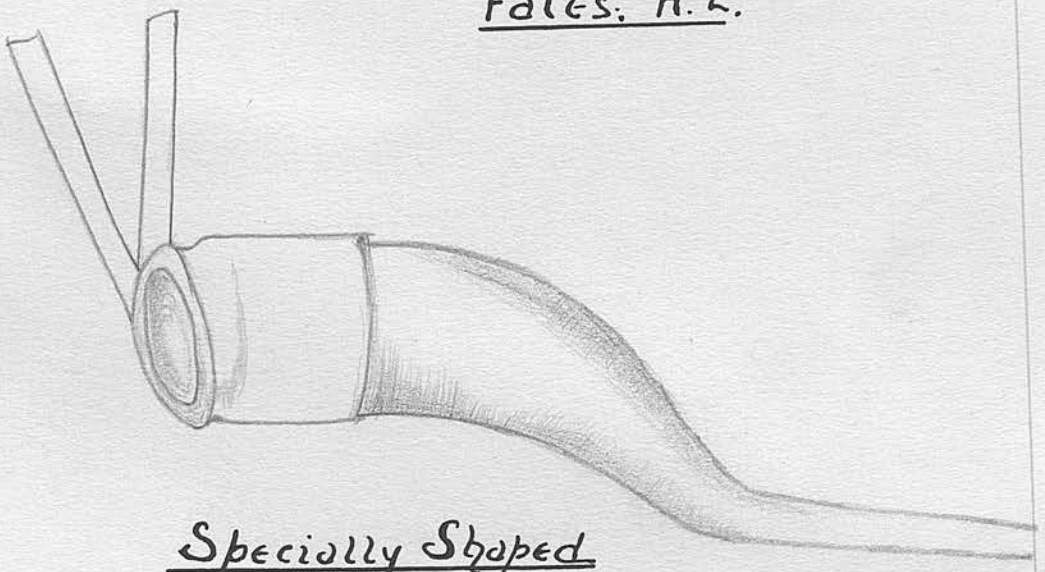
New. York.



After.

Courtney: A.M. &

Fales. H.L.



Specially Shaped Glass Tube with Rubber Attachment

Du Bois of New York, U.S.A. (1911) describes his method for collecting the excretion of infants, claiming that a mother can nurse her infant while it is under restraint. The infant is strapped on to a special mattress which is laid on to a specially built wooden frame. For a urinal, he follows Talbot's technique, which, he states, he has read about. There is this difference, that he allows the test tube to empty directly into a flask. He says he has kept an infant for three days on this frame collecting all the urine and faeces.

1911.

In the same year Howland and Cooke (1911) describe their technique for a metabolism bed. "Male babies only may be used. The penis is placed in a glass or metal tube held against the symphysis by a rubber waist-band with perineal straps and connected with the collecting flask below by rubber tubing."

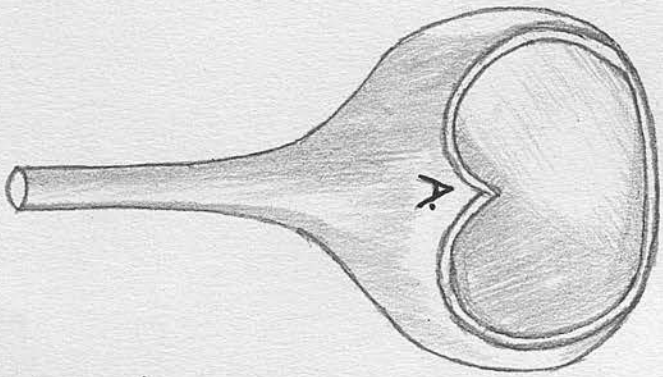
Courtney and Fales (1915) describe what they call "a comfortable arrangement for the separate collection of urine and faeces of male infants. A modified glass tube fitted with a rubber sleeve which they call the 'Finkelstein' rubber attachment is fastened by two bands round the waist, and runs directly into an ordinary /

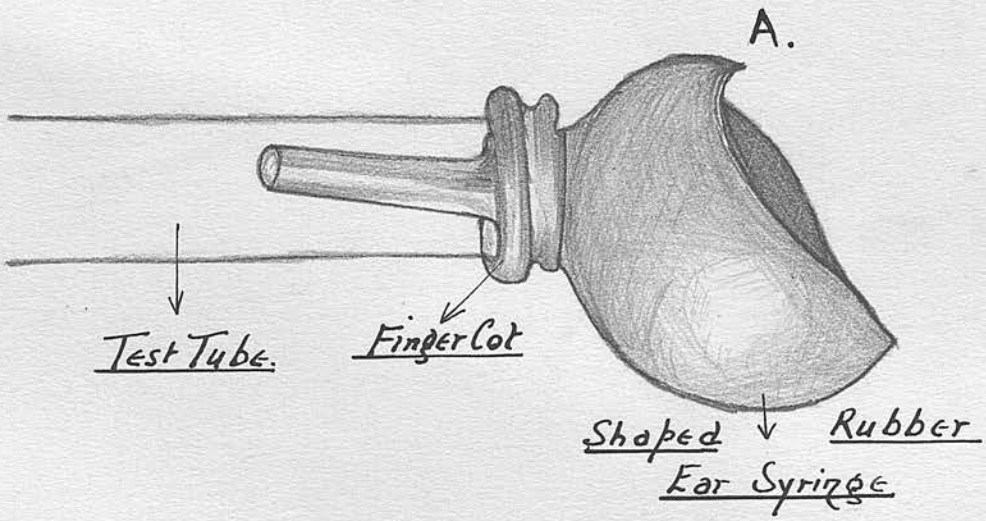
1915.

After

Rub. H. O.

Cleveland.



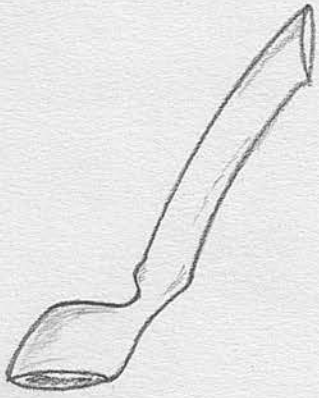


ordinary male glass urinal. The glass tube is large enough to contain both penis and scrotum. With its use, the infant must be pinioned down.

"A suggestion for the collection of urine in female infants" is made in this year by H. O. Ruh (1917) of Cleveland. He says "The following apparatus is extremely simple; the materials are always at hand or can be easily obtained.....A common rubber bulb ear syringe, some adhesive tape and a test tube are the only materials required. The cuts are made in the ear syringe as shown in the illustration. Care should be used to make the tip (A) quite large so that it will fit snugly into the fossa navicularis. The more slant there is to the cut into the bulb, the lower will be the position of the tip of the collector. The test tube is fastened to the tip by means of adhesive tape, or by using the finger of a rubber glove of finger cot slipped over the test tube. Two holes are made in the end of this; one for the end of the collector and one for the escape of air. The apparatus is applied to the vulva by means of adhesive tape or, in institutions, by means of a special binder."

Some comment on this apparatus will be made in the next section.

After. Schloss. O. M.
New York.



For: Male Children only.
Abdominal and Perineal
Straps are used to fix it.

Used in Bellevue Hospital.

Manufactured by.
Eimer & Amend.
3rd Ave. & 18th St.
New York.

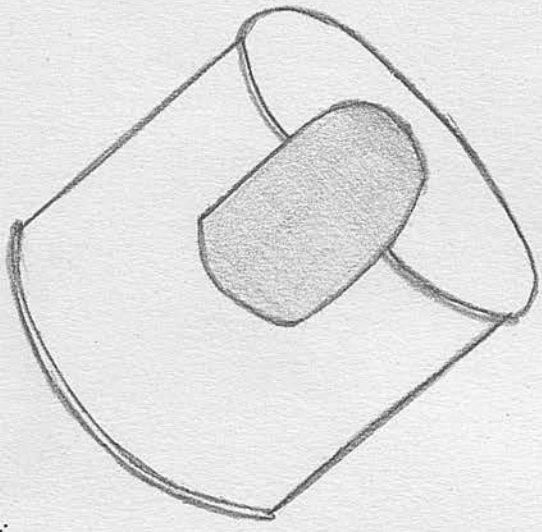
The Schloss tube designed by Oscar Schloss of New York (1918) as a "simple apparatus for the collect-

1918. -ion of urine from male infants," is shown in the sketch. It is made of glass and is fixed on by means of abdominal and perineal straps fastened to a waist-band.

After

Porter. Prof. L. San Francisco.

Carter. W. E. " " " "

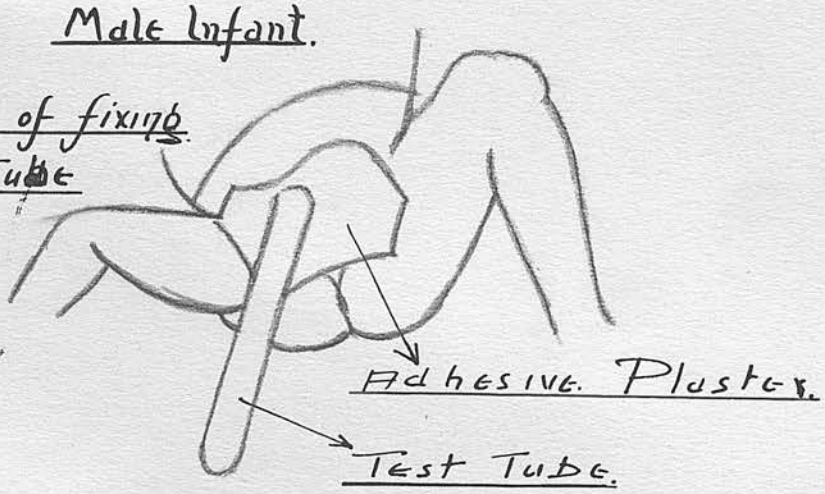


No. 1.

Female Urinal.

No. 2 Male Infant.

Method of fixing Test Tube

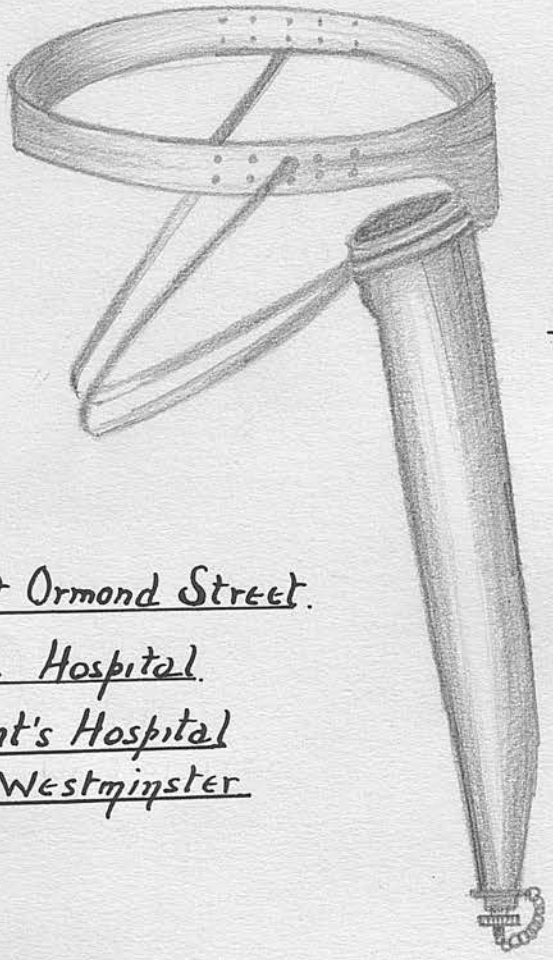


1922.

Porter and Carter (1922) in their text-book "On the Management of the Sick Infant" advocate the use of a test tube for the male. A sketch illustrating their technique is shown. They also advocate the use of a special metal can in the case of the female infant. The use of this weapon, of which a sketch is given, must surely have required some little courage on the part of the physician. Fortunately it is not readily procurable.

After

Paterson. D & Leviseur. E.A.



made of.
Rubber

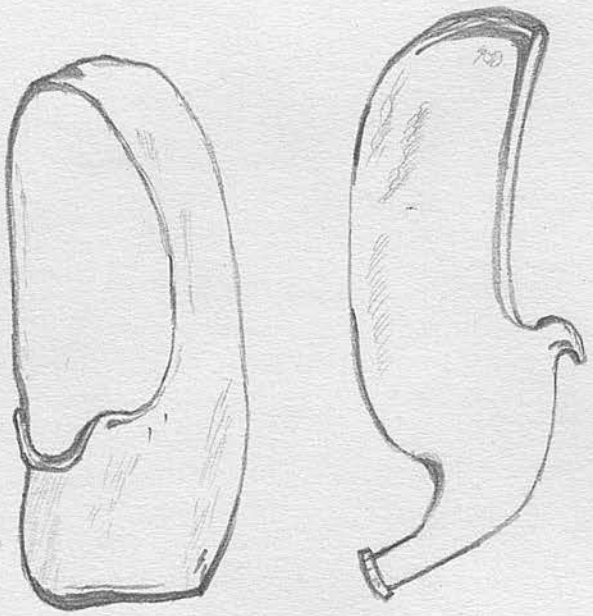
used at
Great Ormond Street.
Guy's Hospital.
Infant's Hospital
Westminster

manufacturer
Allen & Hanbury
London

Paterson and Leviseur (1923) "designed an apparatus to overcome the difficulties in collecting specimens of urine from small female patients." They state "It is most efficient in babies too young to sit up;" - presumably this means less than 6 or 7 months old - "the urine, however, being collected equally effectively in whatever position the child may be lying. The apparatus consists of a vulval pad or ring, oval in shape, which closely fits the perineum.

1923. From the vulval pad inferiorly hangs a conical bag with a screw tap at the apex, and by its use, single or 24-hour specimens of urine may be collected. It is comfortable, easily and rapidly applied, readily sterilisable either by boiling or, preferably, in 1/20 carbolic solution. It is washable. In cases of pyelitis, it is extremely useful, in that the bag may be emptied through the screw tap without removing the pad. The variation in alkalinity or pus contained in the urine may be closely observed. The appliance may be used with even greater facility on male infants." This apparatus does not differ very materially from that of Raudnitz (1883) or Bendix and Finklestein (1900) except that the opening is adapted for females. Though possibly /

No. 1. No 2.



After:- McBride. R. H.
Dept. of Pediatrics
State University of Iowa.
U.S.A.

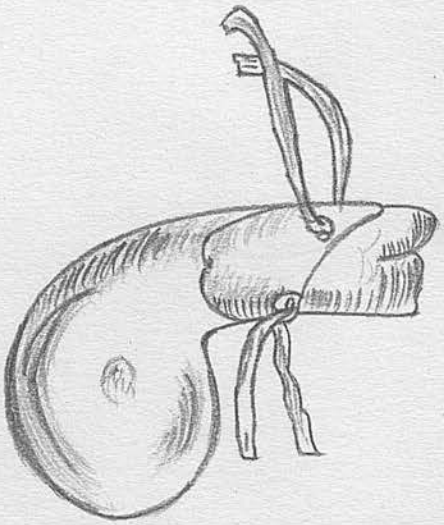
No. 1. Single Specimen Model.

No. 2. 24 Hour Specimen Model.

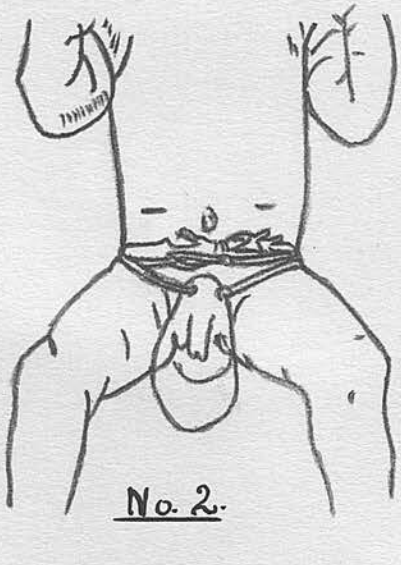
possibly less cumbersome than that of Marfan (1900) it is not so useful, for there is no provision for ventilation. Since there is no means of indication of the time at which urine is passed, it is manifestly impossible to justify the claim that "by its use single specimens of urine may be collected" by it. The most that could be said is that 24-hour and part 24-hour specimens may be collected with, perchance, a single specimen if one happens to observe the infant passing urine into a clean empty bag.

A very good suggestion under the heading of "A New Infant Urinal" is made by McBride of Iowa (1926). The urinal is made of glass and the sketch shows quite clearly its shape. It would require, of course, to be fastened on by means of abdominal and perineal straps. His single specimen type has the objection that one would never know when urine had been passed, and so it may almost be said to be redundant.

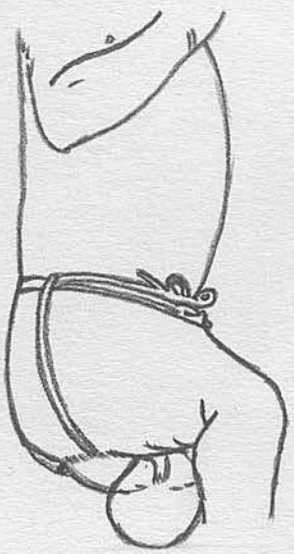
1926.



No.1. Glass Urinal with Sterile Wool Stopper.
Capacity. 50.cc.



No. 2.



No. 3.

Showing method of fixing on to infant.
Note: Perineal Straps.

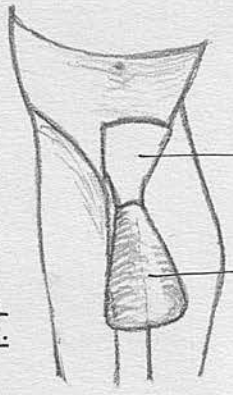
After. Gustav Haselhorst
Univ. Frauenklinik
Hamburg.

Manufacturer.
Albert. Dargath.
Pferdemarkt. 66.
Hamburg 1.

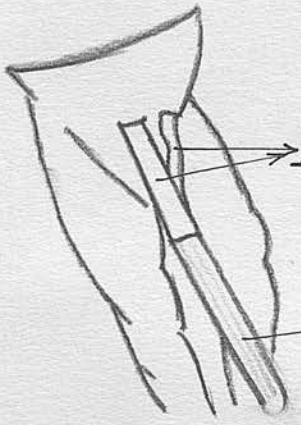
1927.

Haselhorst of the University Frauenklinik, Hamburg (1927) had made to his design a special glass urinal for use with male infants. Reference to the sketch will show clearly its shape and the manner in which it was intended that it should be used.

After Feer. Prof. E.
Zurich.



No. 1.
Female Infant.



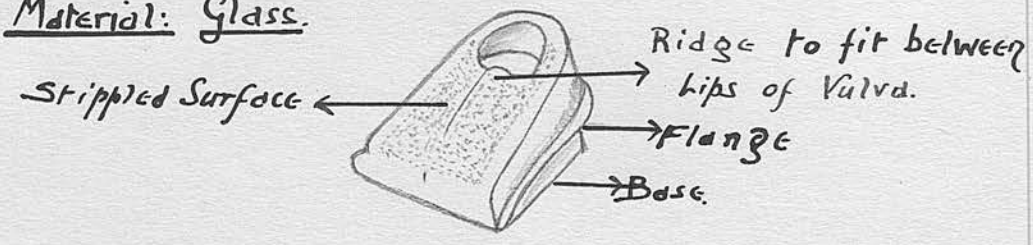
No. 2.
Male Infant.

In this year the use of the test tube for males is still being advocated by Feer (1928) in his
1928. "Diagnosis of Childrens' Diseases." He fastens it on rather differently from Porter and Carter. For the female he suggests the use of an Erlenmeyer flask kept in position by strapping.

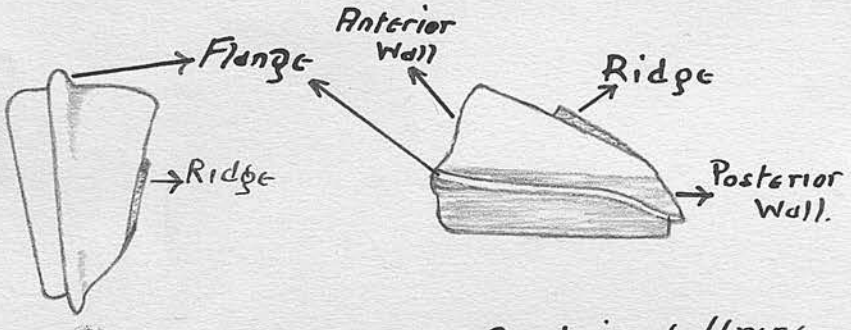
Burnheim, R. (1928) is said to have described a new apparatus for male and female infants but, so far
1932. I have not been able to obtain the journal in which the publication is made. The reference is given.

After. Prof. Howard Hailey.
Emory University
Atlanta. Ga.

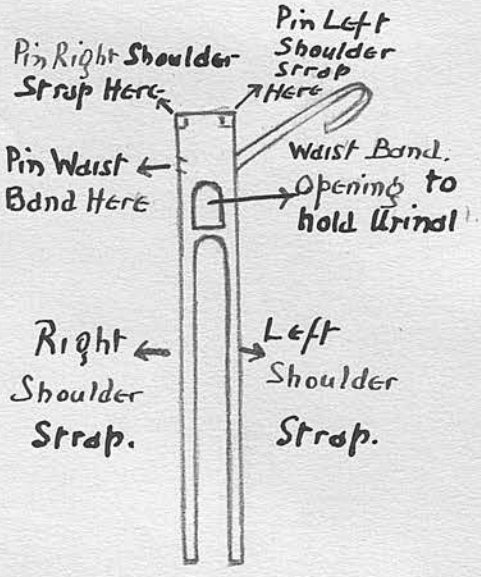
Material: Glass.

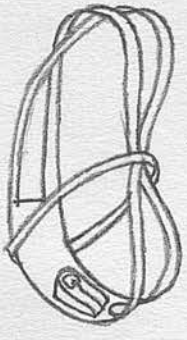


Antero Lateral View.



Empty Elevation Containing Urine.





Postero-Lateral View Showing fixed position of Urinal.

Hammock Napkin
or.
Harness

NOT TO ANY SCALE.

A receptacle for obtaining specimens of urine from infants is described by Hailey (1932) Professor of Dermatology in Emory University, U.S.A. It is a glass receptacle used in conjunction with a special harness. His illustrations, which are reproduced here, show the special apparatus required. He states that "the front or face of the urinal is so moulded that it anatomically fits the child. There is a ridge which fits between the lips of the vulva." "The surface is stippled to increase friction, there--by reducing slipping of the urinal."

1932.

He claims for his urinal the following advantages:

(1) Excoriation, infection and accompanying pain is abolished, since adhesive is not applied to the skin.

(2) Uncontaminated specimens are obtained if the apparatus is properly applied and pinned snugly.

(3) The time of voiding may be noted without removing the apparatus.

(4) The Hammock Napkin may be adjusted so that it is practical for all infants and untrained children, male as well as female.

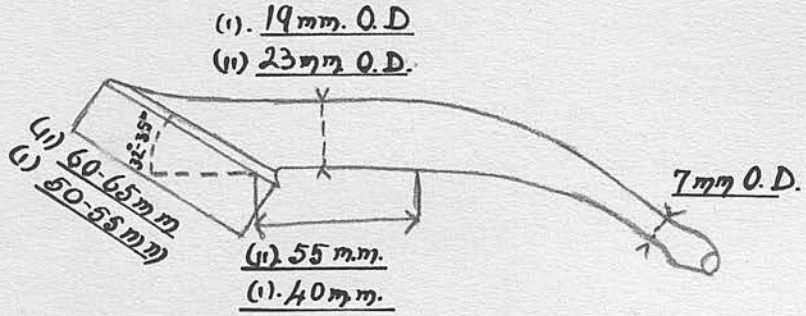
(5) Constant attention of the nurse in charge is no longer necessary while obtaining a specimen.

(6) The urinal may be used by an intelligent person /

After:

Hoagg. Lynne H.

New York.



For Male Infants Only.

Made in Two Sizes.

person without the aid of the "hammock napkin", using an ordinary napkin to hold the urinal against the body.

(7) When the child is wearing a shirt of non-elastic material, the hammock napkin may be pinned to the shirt in front and behind, not using the shoulder straps. Even here it is advisable to use the waist strap.

The following important information is not given:-

(1) The capacity of the urinal.

(2) Its dimensions.

(3) The maker.

(4) The range of sizes, if any.

Lynne A Hoagg (1932) describes an apparatus for the quantitative collection of urine. It is only of use in male infants and, as a glance at the sketch will show, is but a modification of the test tube. It is made in two sizes and is intended for use with a distant collecting vessel

Shoji, T. of Taihoku, Formosa, (1934) describes an an apparatus for male infants. As he gives no illustration and I am unacquainted with some of the pieces of apparatus which he mentions, I will quote much of his article in full:- "I used a glass tube, 3-4 cm. long, and of such a width as to fit the penis of /

1934.

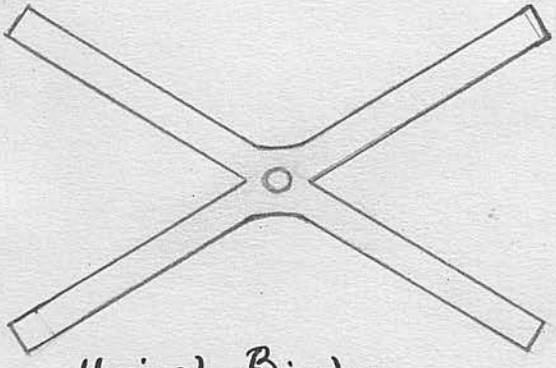
of the child; a lumen of about 1·5 cm. is suitable for almost any new-born boy. The penis of such a child is so small that it is in an upright position when the child lies on its back. In order to prevent stagnation of the discharged urine above the penis, the tube has to be bent at a suitable distance from its base in such a way that the free end points downwards.

To fasten this tube to the penis, it is inserted into the basal pad of an M.R.C. Rubber Urinal Bag; the bag itself is much too heavy and cumbersome for a little child, so I cut it off and replaced it with a Queencke's neck ice-bag, which is very light and soft, and does not incommode the child in any way. Whenever the child has made water, the bag is untied, and the urine removed to another container provided with some suitable disinfectant.

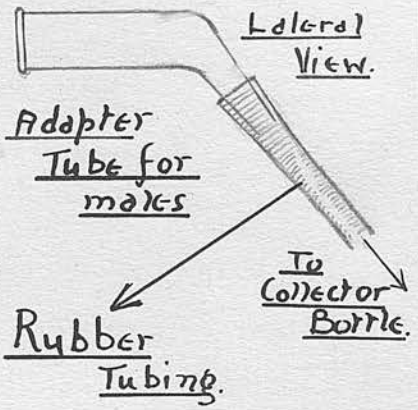
When the child's 24-hour urine has been collected, it is advisable to change the urinal bag, and to use it again only after a thorough washing and drying.

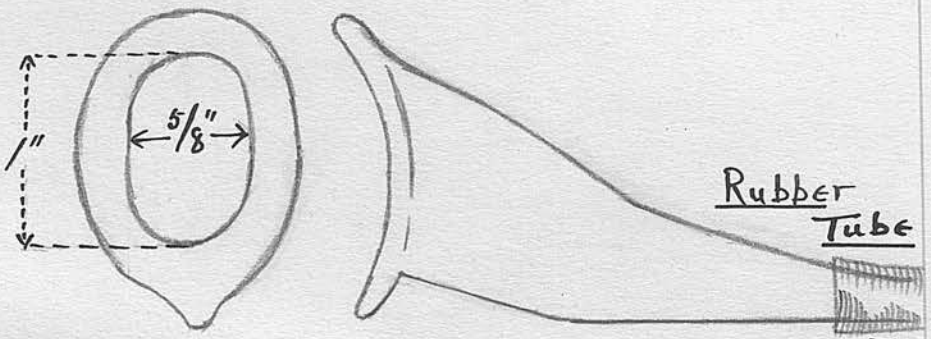
While/

After. Lee E. Farr.
Rockefeller Institute for
Medical Research. N.Y.



Urinal Binder.





Adapter Tube for females.
actual size.

While the collection of the urine is going on, it is well to raise the upper half of the infant's body, in order to prevent more thoroughly any stagnat--ion of urine above the penis. For this purpose I had a special rattan bed made for the babies, with an obliquely rising bottom, and always laid them on this bed."

It is obvious that here we are still using a modification of the test tube.

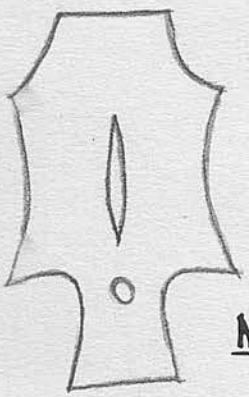
Farr's (1935) so-called adapter of which there are sketchs given, may be said to be nothing more than a test tube for a male infant and a modified test tube rather like Lynne A. Hoagg's for the female.

1935.

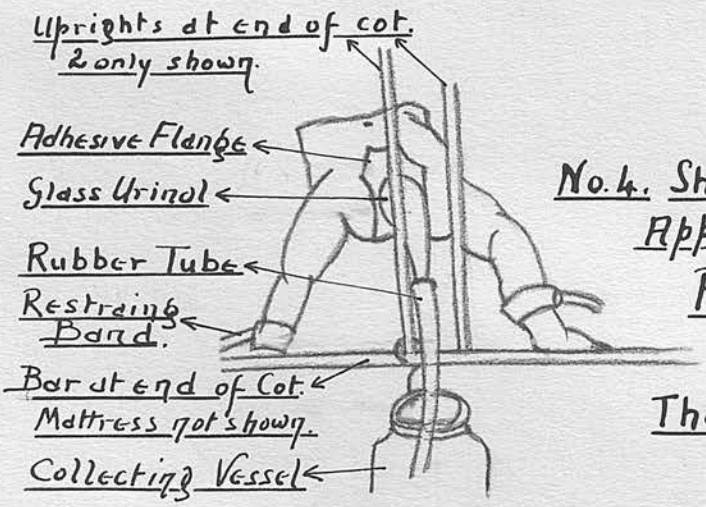
No. 1.
Glass Urinal.

No. 2
To show Urinal inserted through apperture in Adhesive Cloth which forms a flange.

After.
Paul Ujsághy.
Kinderklinik
Universität.
in Pécs.



No. 3. Shape of Adhesive Cloth.



No. 4. Showing Apparatus in Position

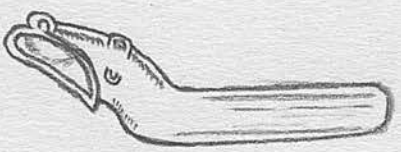
Note:
The restraining Bands.

Glass Urinal made in 2 sizes by
Alexander Huber
Gellert Platz. 4.
Budapest. I.

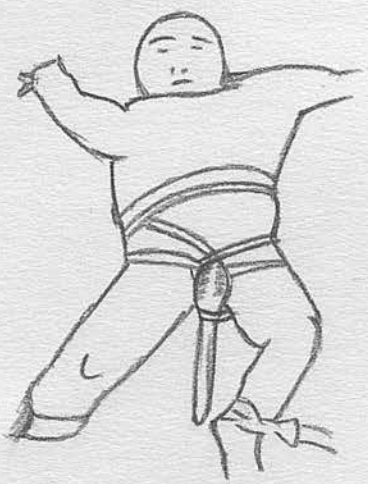
1937. Ujsaghy, P. (1937) describes an apparatus for female infants which very closely resembles that of Schabad. He does not appear to have known of the latter's apparatus, though the description is given in Vol. XLVIII of the same journal in which he himself writes.

After: Tobler. W.

Bern.



Glass Urinal: not to any scale



Showing method of application and the need to fix the infant so as to restrict movement

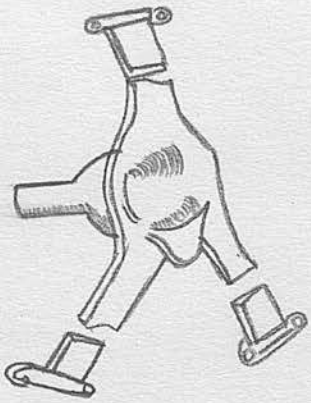
Manufacturers of Apparatus

W. Wütrich & Haferkorn.
Laboratoriumsbedarf und Glasbläserei
Engehaldenstrasse 20.
Bern.

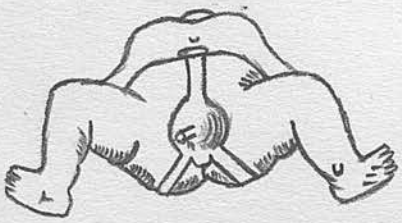
1938.

From Berne, W. Tobler (1938) writes, giving his modification of the test tube for use in male infants. Thereby he admits, of course, that the test tube is not, in his opinion, satisfactory.

No.1.



No.2.



After. Cohen. R Louisville. & Blatt. M.L. Chicago.

No.1. Sketch of Rubber Urinal.

No.2. Urinal in position.

1940.

Cohen, R., and Blatt, M.L. (1940) describe the most recent addition to the ever lengthening list of apparatuses designed as infant urinals. It is intended for female infants only, but I think might well be also used for small male infants where it is big enough to contain both scrotum and penis. It is, however, a specially made article, not readily obtainable, and probably only in one size.

DISCUSSION.

While much effort has been expended and great ingenuity displayed in many of the attempts to collect and examine urine in infants and newly born babies, there are, without a shadow of doubt, certain methods which we may dismiss from consideration. Not because some of them may not have a useful place in clinical technique, but because they, one and all, are of little value from the research worker's point of view, or because they can readily and easily be replaced by better methods.

Hodann's (1855) examination of the wet napkin certainly comes into this category, and yet it is a most valuable procedure in the ordinary clinical examination of the infant. The odour of the wet napkin may give the clinician valuable information. Moreover, he must be able to reassure a nurse or an anxious mother that uric acid staining is not blood staining.

Hecker's (1857) patient simple method may be all very well for the procuring of a small quantity of urine, but it is time consuming, unreliable, and surely tedious in the extreme. Moreover, it is doubtful if any reasonable quantity could be obtained by this method within, say, 12 to 24 hours.

Pollak's (1869) oilcloth/

oilcloth, despite its continued advocacy in the form of a macintosh sheet by eminent men like Still (1927), and Ashby and Roberts (1922), was condemned by Pollak himself for good and sufficient reasons which he himself gives and which have already been mentioned.

Bouchaud's (1864) technique is surely nothing more than an invitation to contamination of the urine and maceration of the skin, while Camerer's (1876) attempts at improving upon it savour of the ridiculous.

Gerstenberger's (1909) apparatus we may dismiss as being unworthy of the scientific era in which its construction was described.

The materials used in the construction of the various urinals are glass, rubber and enamelled metal. There is only one example of the latter, that of Porter and Carter (1922) for use in the female. From its shape it does not suggest to one a high degree of efficiency; and it does suggest possibilities of damage to the patient. It may well be discarded with the other methods already referred to as being unsuitable and undesirable.

With these few methods dismissed, however, there still remain a fairly large number of descriptions of urinals or of methods of obtaining urine from infants. It /

It is soon apparent, however, to anyone reading them, that there is a great similarity between many of them. In some cases indeed the methods are almost identical suggesting that the latter writer had no knowledge of the former, even though he may write in the same journal. A good example of this is the publication of Ujsaghy (1937) in the same journal as the publication of Schabad (1907).

The various methods may be readily classified into three groups as follows:-

1. Catheter.
2. Test Tube.
3. Rubber Bag or Ball.

(1) In a class all by itself and applicable to both sexes from birth onwards is catheterisation, a procedure used by Dohrn (1867), and by Pollak (1869). It is not a desirable technique to employ routinely and is only justified when a specimen for bacteriological investigation is required. The passing of a soft red rubber catheter in either sex, even in the newly born, is not difficult if a suitable size of catheter is used and there is no obstruction present.

(2) The test tube method as advocated by Porter and Carter, and Feer (1928) has been modified in many ways. This need for modification tells us at once that the test tube method is not always satisfactory. The/

The method is simply to enclose the penis within a tube. It was exploited by Pollak (1869), Quinquad (1872), Epstein, Raudnitz (1883), Freund (1898), Bendix and Finkelstein (1900), Teuffel (1907), Talbot (1909), Howland and Cooke (1911), Du Bois (1912), Courtney and Fales (1915), Schloss (1918), Haselhorst (1927), Hoagg (1932), Shoji (1934), Farr (1935) and Tobler (1937). No less than 17 experimenters. In every case the material used in the urinal's construction is glass, and invariably the urinal is in close proximity to the penis - 14 times, in fact, to 3 instances where the urine-collecting vessel is placed at a distance and connected to the penis tube by a rubber tube. This method has the great disadvantage that it is not applicable to girls, and can only be used in boys where there is a penis of useful size. The difficulty occasioned by the small size of penis is a common one in the newly born and it is noteworthy that few of the above experimenters worked with infants of the neo-natal period.

Consideration of the accompanying illustration will emphasise how great this difficulty may be. The infant is a healthy full-time male of average weight. The test tube is $\frac{1}{2}$" in diameter and the coin is a silver threepenny piece. It will be observed that/

that the penis is, relatively, exceedingly small.

Speaking in general terms, one may say that the test tube method is suitable (1) only in the male sex and (2) usually in older babies and infants, and (3) only where the penis is sufficiently developed. Speaking in terms of any particular type of test tube apparatus, we can say that for any serious and prolonged observations:-

(a) A method which does not give reasonable ventilation to the local atmosphere surrounding the penis is not desirable. The hot moist atmosphere which would otherwise result is inimical to a healthy condition of the skin surface. This point is stressed by Hoagg (1932) who says the apparatus "must be loosely attached to allow ingress of air". This difficulty is to a very large extent surmounted if the collecting vessel is placed at a distance from the test tube modification as in Talbot (1909), Hoagg (1932) and Farr (1935), or if with the urine collecting vessel near the infant the external atmosphere has ready access to it as in the methods of Bendix and Finkelstein (1900), Du Bois (1911-1912), and Howland and Cooke (1911).

(b) A method which permits of the infant spilling the contents of the urinal is of nourse not to be considered /

considered. Here it may be said that the gymnastic feats of which an infant, even in the first week of life, can be capable, are no mean performance. Lange (1895) draws attention to the ability of a restless infant to loosen the bandages so that the urine would be lost. In the course of my own experiments a male infant, using its feet only, has been observed to remove a test tube which had been securely fastened on by means of abdominal and perineal straps. This difficulty can be overcome by applying restraint to the infant in the manner of Bendix and Finkelstein (1900) or Talbot (1909) or Du Bois (1911). One hesitates, however, to apply such methods of restraint to a newly born infant when one would certainly meet with objections from the mother who is breast-feeding and probably from the obstetrician as well.

Even with restraint, however, one may not always be successful. From my own observations I am convinced that many male infants can retract the penis to such an extent that it slips out of the test tube altogether.

(c) The sticking plaster method of fixing on the test tube,or its modification, are not to be recommended for more than the obtaining of a single specimen. In prolonged use they traumatise the skin surface /

surface and mostly so in the case of the newly born infant. Lange (1895) and others draw attention to the risk of maceration of the skin, an occurrence which he himself observed.

From the foregoing it will be seen that the most useful methods using the test tube technique are those of Bendix and Finkelstein (1900), Talbot (1909), Du Bois (1911), Howland and Cooke (1911), Courtney and Fales (1915), Schloss (1918), Hoag (1932), and Farr (1935).

It is very noticeable that no less than eight variations of the test tube emanate from U.S.A. some of them from the same city of New York. This surely suggests lack of knowledge, or of confidence on the part of the latest inventor.

(3) The rubber bag technique forms the third class and it may be subdivided into three groups, for all of which a high degree of efficiency can be claimed. This success is due to the fact that all the apparatuses in this class are made on the principle that it is essential to enclose the whole of the external genitalia. Incidentally it also means that in many cases they are suitable for use in female infants as well as in males.

The/

The three groups are:-

(a) The soft collapsible walled type of bag of which the typical example is the condom.

(b) The hard walled apparatus made of vulcanised or semi-vulcanised rubber or of glass.

(c) The resilient shaped bag made of soft rubber and resembling a ball.

Martin and Ruge's (1876) first attempt using gold-beater's skin falls under the heading of group (a) as does Cruse (1877), Rüdel (1894), Rey (1895), Bendix (1896), Michel (1896), Lange and Berend (1897), Keller (1898) and Reubner and Heubner (1898-1899). It may be said that they all achieve a high measure of success. This is due to (a) the fact that they are used only in male infants where the whole of the external genitalia are well developed; (b) the enclosure of both scrotum and penis inside the rubber bag thus ensuring more reliable fixing of the apparatus to the infant and less risk of loss of urine passed.

There are, however, certain objections to their use. (a) The rubber material may be porous and not contain the urine once it is passed. (b) Except by constant watching one does not know when urine has been passed. (c) One cannot measure the volume of single specimens since one can never be sure that one is dealing with a single specimen. (d) If the rubber/

rubber bag, bottle or condom is not large enough it may be filled to overflowing. (e) The external genitalia may be bathed in urine with considerable detriment to the skin surface. (f) Urine collected under these circumstances cannot be preserved properly for chemical investigation later. (g) The rubber ring method of fastening may lead to (1) oedema of the part; (2) ulceration - pressure sore by the rubber ring; (3) mechanical obstruction of the urethra.

Almost all of these objections are removed by the use of a distant collecting vessel in conjunction with the rubber condom, and a good example is seen in the metabolism bed introduced by Bendix (1896).

The first and second of these objections are mentioned by Cruse (1877) as having occurred during the making of his experiments.

Group B. This type of urinal is seen in the inventions of Schabad (1907), McBride (1927) and Hailey (1932) where it is made of glass and Marfan (1897) where it is made of semi-vulcanised rubber. The objections to its use are in a large measure the same as those already mentioned for the preceding group A. If the urinal is in close proximity to the infant as in Hailey's model and in McBride's single specimen model (a) constant watching for the passage of urine is necessary; (b) the infant may wriggle about

and/

and cause the urine to be spilled; (c) the urine cannot be preserved; (d) one cannot measure the volume of single specimens since one can never be sure that one is dealing with a single specimen; (e) despite Hailey's assertion to the contrary I feel sure that pressure sores may be caused or the skin of the external genitalia may be soaked in urine and macerated; I think this is all the more likely to happen since Hailey also states that constant attention of the nurse in charge is no longer necessary while obtaining a specimen. This, I interpret, as an invitation to the nurse to relax her vigilance.

With the use of a distant urine collecting vessel objection (a), (b), (c), (d) are removed, and (e) and (f) remain as dangers: The greatest difficulty of all remains, namely, that every example of apparatus in this group is not readily available to either the clinician or the research worker and must be specially made by a special technician. Moreover, there is no flexibility in the size of the urinal so that what may fit one infant will not fit another, indeed to reiterate Cruse "the apparatus functions perfectly but one may have to wait a long time to find a baby to fit it".

And so we turn to the last group, the soft rubber ball or bag (Group C). It is suitable for males/

males and females of all ages provided a good fit can be obtained. This type of urinal used with a distant collecting vessel is undoubtedly the nearest approach to the ideal which we can get. With a good nurse and careful technique all the objections already enumerated can be met and overcome. Schabad's (1907) example is excellent while Cohen and Blatt's (1940) is no less useful in small males than in females, though it was designed only for the latter.

The problem of not only procuring this type of apparatus but of procuring it in a sufficient variety of sizes remains, however, an insurmountable barrier. The demand is not sufficient to make it worth a rubber manufacturer's while to give time and material to the making of such articles. Indeed he would probably be considerably out of pocket if he attempted it. Moreover, rubber apparatus used for this purpose does not tend to have a very long life as I will show later, thus making the cost of replacement prohibitively high for the few who would make use of the appliance.

SUMMARY /

SUMMARY.

1. The whole literature on methods of collecting urine from infants is surveyed.
2. There is only one publication in the medical press of the British Empire on the subject.
3. A modification of the test tube used with a distant urine collecting vessel is suitable in some male infants, but not in all neonatal infants.
4. The ball method is suitable, used with a distant urine collecting vessel. It may be used in females and males.
5. The methods of collecting urine described by early investigators of the subject are not reliable.
6. There is no description available of a readily procurable or readily improvisable apparatus with which it is possible to collect 24-hour specimens of urine for a few consecutive days from the same infant in either sex.

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S E C T I O N . II.

A NEW INFANT URINAL .

INTRODUCTION.

An investigation into the urine, no matter how superficial, presupposes an ability to procure the necessary specimens of urine. This in the newly born infant is"sometimes a matter of difficulty" (Griffith and Mitchell, 1933); "troublesome" (Finlay, 1933); and "requires patience and care" (Spence,1934).

While it is generally accepted that part 24-hour specimens of urine can be procured from infants - though some of the methods advocated for its collection do not always appear to be desirable or even in the best interests of the infant - the collection of a full 24-hour specimen, which is essential for an investigation to be of any value, is a matter of real difficulty. This difficulty is admitted by Capon, (1933), Still, (1925), Hutchison and Hunter, (1935.)

The collection of a series of 24 hour specimens from the same newly born infant must surely be even more difficult; and indeed Mitchell and Nelson, (1935), maintain that "During infancy it is only in boys that continuous examinations are feasible - - -".

Yet the daily urinary output of the newly born infant /

infant has been measured, and Howland, (1926) gives a table setting forth what he calls the "average daily" output from birth. This table which is widely quoted by Amberg (1924), Finlay (1933) and Hutchison and Hunter (1935), is compiled from a number of observations made by various continental observers, and reported chiefly in the German literature, e.g. Cruse (1877); Martin and Ruge (1876); Schiff (1893) Camerer (1876) and others.

It is, however, a misnomer to call this table the "average daily" output. Such a title implies that one average figure for the day should be given whereas in fact two figures are given which suggest rather the daily range within which the output may vary.

AVERAGE DAILY QUANTITY OF URINE IN HEALTH.

Age.	Grams.
First 24 hours.	0 - 60
Second 24 hours	10 - 90
3 - 6 days	90 -250
7 days to 2 months	150 -400
2 months to 6 months	210 -500

It is pleasing to notice that this anomalous title with its table has not been included in the latest edition of Holt's Diseases of Infancy and Childhood (Lyttle 1939). Additional continental references - Herz (1888), Lesni and Merklen (1901), are mentioned by /

by Griffith and Mitchell (1933), who also give a table of daily secretion of urine based on the observations of continental writers.

Much of the work done by these early continental investigators cannot be accepted at its face value eith-:er because their methods of obtaining the urine were unreliable, or because they did not take into consider-:ation the nature and amount of the infant's intake.

Further, sometimes a publication is quoted as authority upon which to found statements concerning the output of urine by the newly born infant, and when one comes to read the original article quoted, one finds that the author of it has done no original work on the subject, but is merely quoting earlier investigators.

Herz (1888) is one such quoted authority in whose publication I have not been able to find any re-:cord of personal observations in the newly born infant.

Anna Schabanova (1879) is another who made no personal observations at this age period.

Moreover, among the authorities quoted one finds sometimes a name and a reference given which it is im-:possible to verify since the original article cannot be procured, even in the best medical libraries.

Camerer (1876) is one such example. While the inaccessibility of a publication is no measure of the value /

value or accuracy of an article in that publication, one may be pardoned for speculating as to the frequency with which such a publication is quoted.

It would appear that there are no sufficiently reliable observations by either British or American workers. This may or may not confirm the difficulty to be faced in any such investigation rather than any lack of interest in the subject.

Further, merely to record the volume of urine passed is in itself a matter of little importance. It is the chemical composition which is of greater interest: the total chlorides, total nitrogen, etc., the presence of albumen, of vitamin C, of sexual hormones, etc., the relationship of products of metabolism in the urine to the quantity and quality of the food ingested.

Such observations, however, cannot be determined accurately unless the urine can be collected by a satisfactory method for several consecutive days from the same newly born infant. To quote Amberg (1924) on the composition of the urine - "Substances intimately connected with the metabolic exchanges which are found in the urine of the adult are to be found in the urine of the infant and child. If some such substances have not been demonstrated as yet this may be due to the greater difficulty of collecting /

collecting urine in sufficient quantities from infants and children in a manner free from objection".

How then is one to accomplish this? The very multiplicity of methods for the collection of specimens of urine suggested in the various textbooks on Pediatrics is significant and suggests further that the difficulty is really greater than some writers will allow. The following are the different methods suggested in various textbooks on Diseases of Children for the collection of presumably part 24-hour specimens of urine.

1. First and least satisfactory, one is recommended to leave in contact with the genital organs of the infant a piece of absorbent cotton wool, which can, after having absorbed urine passed by the infant, be squeezed out into a glass. (Griffith and Mitchell,1933; Findlay, 1933; Holt and Howland 1926).

2. Ask the nurse to awaken the infant from sleep and at the same time to exert steady pressure over the bladder. (Capon,1933; Findlay,1933).

3. Exposure to cold air. This hardly seems to be a desirable procedure. (Morse, 1926; Capon,1936).

4. Application of a sponge over the pubic region is advised by Capon,1936. He does not state the temperature of the sponge, not even whether it should be hot or cold.

5 /

5. To allow the infant without a napkin on, to lie on waterproof macintosh or rubber sheeting until some urine is passed so that the urine may be collected in a suitably arranged hollow or dip in the material. (Griffith and Mitchell,1933. Still, 1927). Holt and McIntosh (1939) are even more drastic in their treatment of the patient, for they say "place the infant, naked, on a sheet of waterproof material, bolstered up around him in such a way that he lies in a depression".

6. For the male infant, an almost universal recommendation is the placing of the penis in a wide-necked small bottle or flask, or in the mouth of a suitably sized test-tube, which is fastened to the infant by means of adhesive strapping, or by suitably adjusted tapes. (Morse, 1926; Garrod, Batten, Thursfield and Paterson, 1929; Marriott,1935) Mitchell and Griffith,(1933) suggest the use of a condom instead of a bottle.

7. For the female infant it is suggested by some that a vessel with a mouth sufficiently large to cover the vulva might be held in position by adhesive tape or ordinary tape or by the infant's diaper (Capon 1933). For this purpose there is suggested a test-tube, an Erlenmeyer flask, a small cup (Holt and Howland 1935), a large mouthed bottle, a cage-bird's seed trough (Griffith and Mitchell,1933, Marriott 1935) /

Marriott 1935), a padded bowl (Garrod, Batten, Thurs-:field and Paterson, 1929).

8. The infant might be allowed to lie on a small rubber air ring beneath the hole in the centre of which a collecting vessel has been placed. (Griffith and Mitchell, 1933).

It is also pointed out by several writers that success is most likely to be attained if the attempt is made at the time of nursing or taking fluid.

In several instances it is observed that the methods suggested in textbooks for the collection of specimens of urine do not change from edition to edit-:ion, and sometimes not even from editor to editor; e.g. Findlay in 1933 - the fifth edition of the book - still proposes collecting specimens in the manner de-:scribed in the first edition published in 1898 by the late Dr. John Thomson.

The use of a metabolism bed has been suggested, but it would appear that this merely emphasises the real difficulty which exists in the collection of spec-:imens of urine.

It is stated by Spence (1934) that "difficulty arises only in the case of dehydrated female infants with diarrhoea, but even from these an unmixed speci-:men can usually be obtained shortly after giving a 10% solution of cane sugar to promote diuresis". Such promotion of diuresis in the dehydrated infant, which is still loosing fluid by the bowel does not ap-:pear to me to be very desirable.

While /

While there is universal approval that the most certain of all means is catheterisation, which, however, should not be resorted to unless absolutely necessary, it is remarkable that in not one single instance is any reference made to any of the special methods suggested or referred to in the preceding section. Here it might be said that in the most recent edition of Nursing and Diseases of Children, that admirable textbook edited by Alan Moncrieff, no directions of any kind are given to the nurse in the matter of collecting specimens of urine from either infants or children. Is this an oversight, or is the subject discreetly ignored? Thus in any investigation of the urine in the newly born infant one is brought at once face to face with a most difficult problem: how to collect urine in sufficient quantity from infants in a manner free from objection.

An appliance of some description was obviously necessary, and in quest of this but without much hope of success, I visited various instrument and appliance makers. My inquiries were listened to sceptically, and I am not sure but that some doubts were entertained regarding my sanity, because I insisted that the appliance must be capable of collecting /

collecting a 24 hour specimen of urine. All to no purpose did I point out that there were tables in existence setting forth the daily amount of urine excreted by infants from birth, and that therefore there must be in existence some appliance for the collection of 24-hour specimens. I pointed out in Allen and Hanbury's catalogue the appliance used in the Great Ormond Street, Guy's, and Westminster Hospitals, and designed by Paterson and Leviseur, only to be told that the particular instrument maker had never been aware that such a thing existed. Unfortunately that particular apparatus was not likely to be suitable for my purpose, and I was thrown entirely on my own resources in order to find a solution of the problem. This solution was found in the following manner, and prior to my undertaking the survey of the literature given in Section 1 of this thesis.

EVOLUTION OF URINAL.

I first decided that the appliance which I would make must comply with certain requirements laid down beforehand:- These were that the appliance must be:

1. Cheap.
2. Easily procurable.
3. Easily made, without the need for any special technician.
4. Easily applied by an intelligent nurse.
5. Sterilisable.
6. If possible, unbreakable.
7. Set up no skin irritation.
8. Be comfortable to wear and cause no distress to the infant even if kept on for several consecutive days, if possible, ten.
9. Be durable.
10. Be reliable.

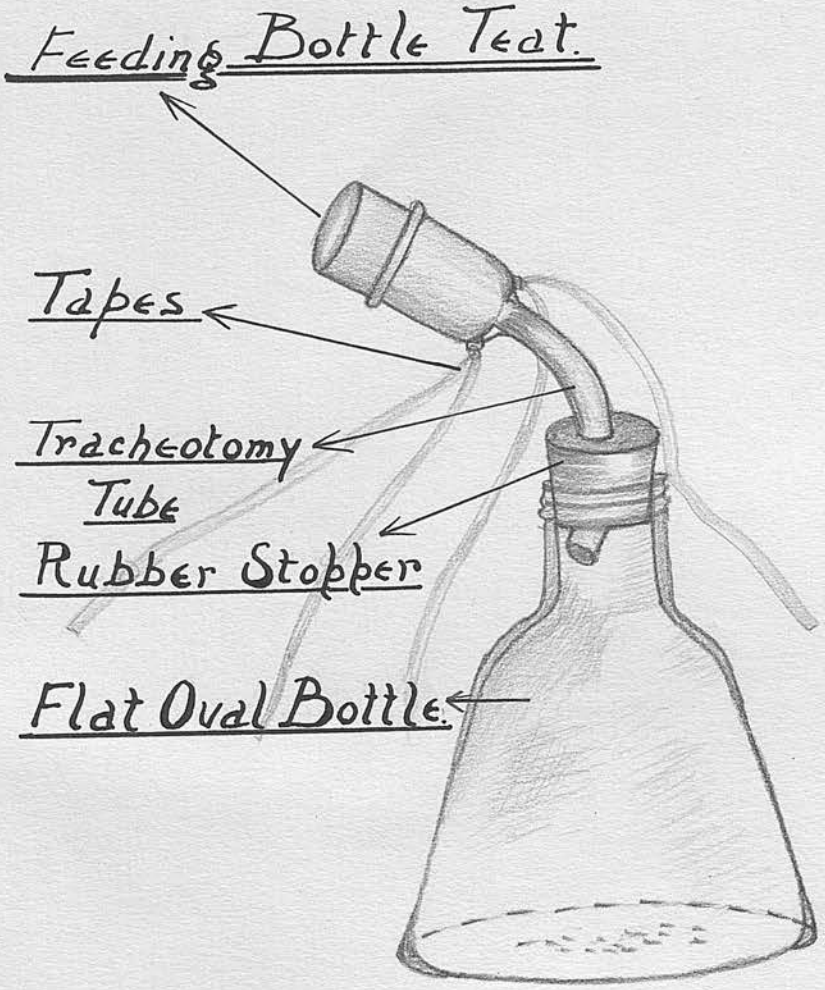
For obvious anatomical reasons it appeared to be likely that success would be more readily achieved in the case of a male infant than in the case of a female, so I devoted my thoughts almost exclusively to the problem /

problem as presented by the male infant.

First, I used an ordinary test tube 6" x 1". This I attached to the infant by means of strapping, having placed the infant's penis in the mouth of the test tube while fitting it in position. By this method it was demonstrated that part 24-hour specimens of urine may fairly readily be obtained, but that for the purpose I had in view there were the following defects:-

1. Adhesive strapping is hurtful to the infant.
2. The penis does not always remain in position in the mouth of the test tube.
3. The test tube may not hold all the urine passed.
4. The contents of the test tube even when collected may be upset by the infant.
5. The bulky test tube is a nuisance when the infant comes to be bathed and breast fed.
6. For good chemical analyses, e.g. to find the pH, one wishes to collect the urine under a layer of paraffin or toluol to prevent deterioration and alteration of the specimen. This is not possible, using a test tube in the manner indicated.

On /


Feeding Bottle Teat.
Tapes
Tracheotomy Tube
Rubber Stopper
Flat Oval Bottle.

On this account the method was discarded as not being free from objection.

In making the second attempt an appliance was made, using the following articles:-

1. A large infant's feeding bottle teat.
2. The inner tube of a silver tracheotomy tube.
3. A small flat-sided bottle fitted with a rubber cork.

These articles were put together so that the inner tracheotomy tube was first passed into the inside of the teat and through a perforation in the end of the teat. This perforation was sufficiently large to allow the tube to pass through, but yet was sufficient--ly small that it caused the teat to grip tightly round the flange of what is normally the external end of the tracheotomy tube. The free end of the tube was now passed on through the rubber stopper and into the bottle.

In attaching this appliance to the infant the penis was placed inside the teat and the bottle was held in place by tapes attached to the bottle and the tracheotomy tube on the one hand and to the binder round the infant's waist on the other. It was a great improvement /

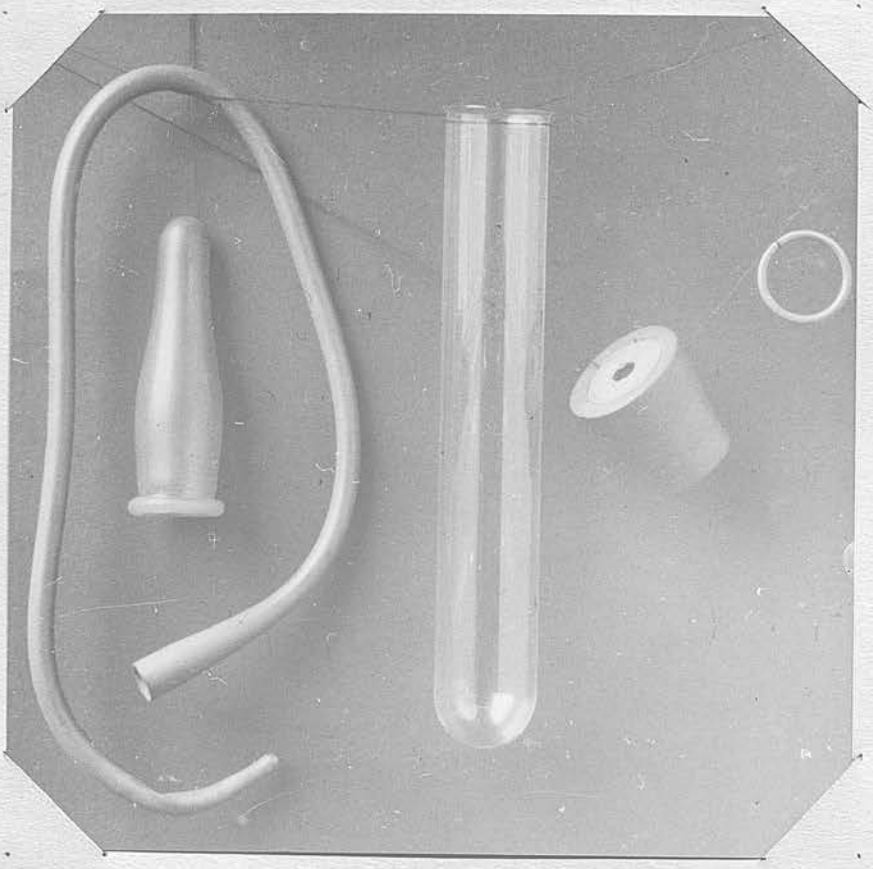
improvement on the test tube method for:-

1. The adhesive strapping was got rid of, and
2. The appliance was not so cumbersome as a test tube.

It still had many of the defects of the test tube, however, and, above all, it was found that except in very small and premature infants the teat was not large enough to contain the penis. Further, a good strong infant was easily able to kick the appliance off with its own feet.

I now made a search for something like a feeding bottle teat but larger and, for the third appliance I substituted a stout finger cot for the teat. It proved worse than useless, being much too pliable and difficult to keep in position.

Fourth. After some little difficulty, I managed to procure a number of teats of varying shapes and sizes, such as are used by shepherds when they require to hand-rear or bottle-feed a lamb. From among them I selected one of a likely size and shape with which to replace the infant's feeding bottle teat on the tracheotomy tube. It did not, however, prove to be a success. The infant's penis could not be kept inside the teat for any length of time with any degree of /



Apparatus Unassembled.

of certainty. The infant was able to hold the bottle between its thighs and then at the same time stretch itself out so that the penis was lifted out of the teat. Further, there was a fair length of about 2" of relatively soft thin-walled pliable teat between the infant and the proximal end of the trach--eotomy tube to which the tapes were attached to fix the appliance to the infant's waist.

Having these defects in mind, I came to the con--clusion that the collecting vessel would be best kept out of reach of the infant and the urine lead to it by a tube.

In making the <u>fifth</u> appliance the following articles were required.

1. A lamb's feeding bottle teat.
2. A metal ring of a suitable size to fit over the teat.
3. A gum elastic or rubber catheter of large bore.
4. A test tube to act as a collecting vessel, and be provided with an air escape and a rubber stopper with a perforation of a size suitable to pass the catheter through.

This apparatus was assembled in the very same manner as /

Apparatus Assembled.

as the previous one, the catheter taking the place of the tracheotomy tube and the test tube that of the bottle. There was this difference, however, a metal ring of an accurate size was fitted over the teat so that it rested against the thick rubber ring at the base of the teat and could not pass right over it. This ring was used to fasten tapes to, so that when the penis was placed inside the teat, the teat could be kept in position by attaching the free ends of the tapes to a belt round the waist.

This appliance was definitely an improvement on the previous ones because:-

1. The collecting vessel could be held upright in the clamp of a retort stand placed on the floor at the cot side and so fill by gravity without difficulty.
2. A sufficiently large vessel could be used.
3. The urine could be collected under paraffin or toluol.
4. The vessel was not likely to be upset by the infant.

It did not, however, fulfil all the requirements which I had laid down as being necessary. It was not reliable. It was possible, and indeed, it frequently happened, /

Unassembled Apparatus.

Note the stud projecting from the ball.

happened, that the penis escaped from the teat. And so, with the failure of this appliance I came to the conclusion that it was not possible to confine the penis by itself, and that the problem must be tackled in some other way.

Sixth:- With this end in view I procured an ordinary ball made of white rubber and having a diameter of 3". In it I cut a hole of a diameter of 32 mm. The size of the aperture was made somewhat at random and actually a two shilling piece was used to draw the outline of the circle on the ball. The rough edges of the hole were readily smoothed down by the application of a red hot searing iron, so that a smooth and rounded surface was obtained. From the centre of this hole I measured quarter of the way round the circumference of the ball and there made another perforation through which I passed the outer tube of a silver tracheotomy tube from within the ball out, so that when in position the ball gripped the tube tightly and the flange on the tube prevented it from being pulled right through. The idea was simply to place the whole scrotum and penis inside the ball and fix it so that the exit via the tracheotomy tube through which urine /

Ball, catheter and test-tube assembled.

urine would run when passed by the infant, was the lowest part of the ball. In short, the ball took the place of the previous feeding bottle teat, while a rubber tube attached to the tracheotomy tube replaced the gum-elastic catheter. In order that the ball might be kept in position, four punctures were made each quarter of the way round the ball from the other, and all equidistant by 2" from the edge of the opening through which the scrotum was passed. Through these punctures from within out were passed ordinary large headed white shirt studs so that they projected outwards. To these outward projections, tapes were fastened; the uppermost two passed up over the infant's abdomen to be fastened to the binder at the front, while the lower two passed between the infant's legs and over the perineum to be fastened to the binder behind.

When trying out this appliance I had three main fears:-

1. The relatively flat circular shape of the ball, aggravated at the exit by the presence of the flange of the tracheotomy tube, might not drain the urine away freely, and since I had already discovered that the infant may pass as little as 2½ to 3 cc. of urine at a time, /

time, it appeared to be quite probable that a good deal of a specimen of urine might lie in the ball and not be collected at all. This is exactly what happened.

2. Oedema of the scrotum and penis might arise due to the mere application of a very well fitting apparatus. Actually no oedema was caused during these observations.

3. The rounded edge of the aperture in the ball might cause an abrasion of the delicate infant skin. Events proved, however, that this would only arise through bad technique and carelessness on the part of the nurse, or prolonged application.

This apparatus then functioned fairly well but had these drawbacks:-

1. A 3" ball was rather large, but substitution of a $2\frac{1}{2}$" ball, which proved to be a suitable size, did not relieve any of the following defects.

2. It did not drain away the urine thoroughly.

3. The method of fastening on with tapes was cumbersome, required frequent renewal on account of soiling, and necessitated considerable care on the part of the nurse.

4. The use of a metal tube in making up the apparatus was inimicable to good chemistry and, therefor, not free from objection.

5. Carelessly applied it might cause abrasion and /

and discomfort to the delicate infant skin.

In making the seventh appliance all of these objections were overcome.

The seventh appliance was made from a No. 6 pear-shaped rubber ear syringe, - Manufacturer, "Ingrams", - one large white collar stud, a rubber tube and collecting vessel with cork and air escape, and a disused motor car inner tube.

It was my intention to substitute this ear syringe for the rubber ball and tracheotomy tube and to fix it on the infant in such a way that the steep conical exit from the syringe would be the most dependent part, and so allow free passage of the urine outwards to the collecting vessel. In the side of the ear syringe a hole was cut and the edges smoothed down by the application of a red hot searing iron to permit entry of the scrotum and penis as in the case of the ball. The centre of this aperture was quarter of the way round the circumference of the ear syringe from the normal exit from the syringe. Directly opposite the centre of this aperture, a collar stud was passed through the wall of the syringe from within outwards. Two pieces were now cut from the motor car tube. /

tube. These were approximately 11" long and ¾" broad. About midway along each strap a puncture was made. This acted as a stud-hole when placed over the stud, both straps being, of course, placed over the only stud used. These straps crossed each other in the shape of the letter X, the collar stud being the point of intersection. One end of each strap passed up over the infant's abdomen to the belt in front, while the other end passed via the perineum to the belt behind. This method of fastening on the appliance was found to work very well indeed and it was the more satisfactory since the rubber straps were not only easily kept clean and could be sterilised and used over and over again, but also cost nothing to procure since the discarded inner tube of a motor car tyre is readily obtained. The belt round the waist may also be cut from the same source, and by the use of four shirt studs, one may fix the belt in position and also fasten the ends of the straps to it in their appropriate places. Needless to say, both straps and belt are made adjustable. In actual practice the ends of the straps were fastened by safety pins to the infant's binder.

With /

With the appliance in position, a short piece of rubber tubing lead from the nozzle of the syringe to a collecting vessel. This appliance in the hands of a capable interested nurse worked admirably; I have kept the appliance on the same infant for five con--secutive days without rest, and without ill effect upon the infant. I have also demonstrated successfully the automatic collection of a 24-hour specimen of urine.

This appliance is:-

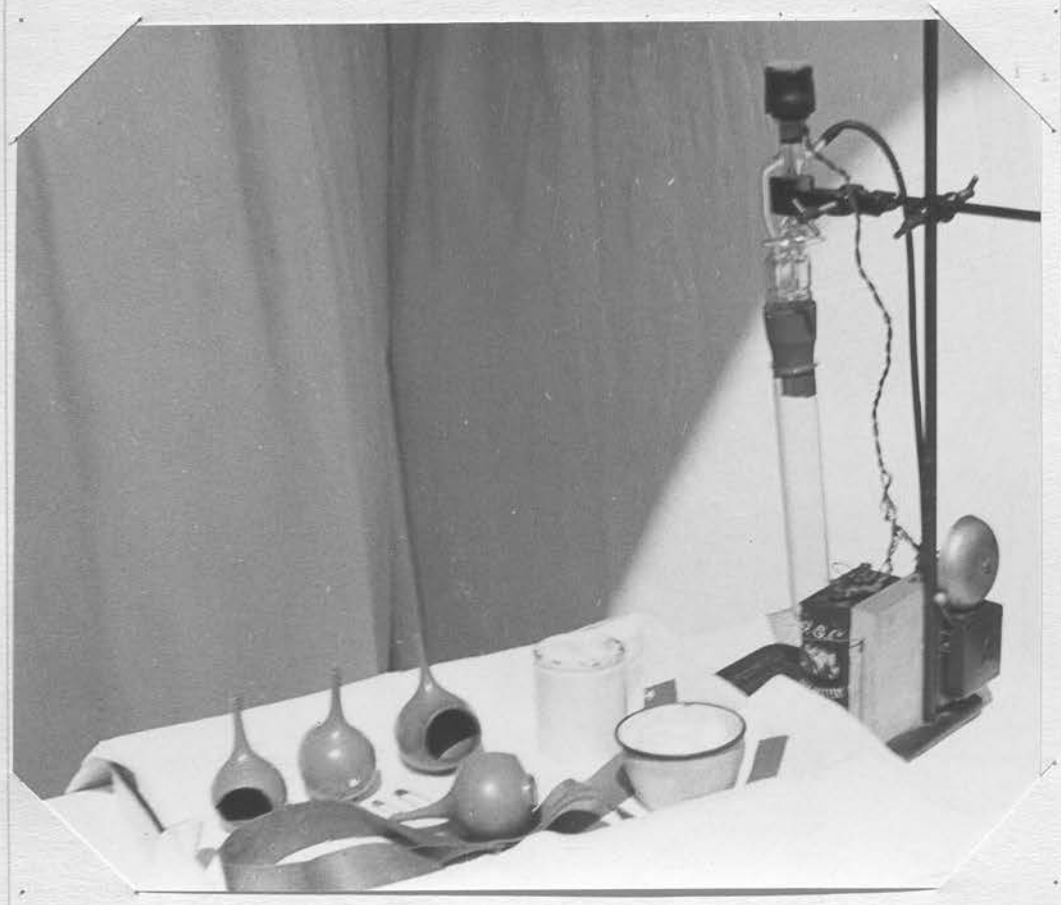
1. Easily procurable.
2. Cheap.
3. Unbreakable.
4. Easily made.
5. Sterilisable.
6. Readily applied by an intelligent nurse.
7. Does not distress the infant.
8. With care causes no irritation of the skin.

Above all, with this appliance one can collect urine from infants newly born, in sufficient quantity and in a manner free from objection for chemical and physical examination.

METHOD OF APPLYING URINAL.

The following is the most accurate method of fitting the urinal upon the infant.

A set tray is required. On this tray, if we are dealing with average sized newly born infants, we have several urinals. These are all cut from pear-shaped ear syringes Nos. 5 and 6 - manufacturer is Ingram's- and have varying sizes of holes in them. Shirt studs,



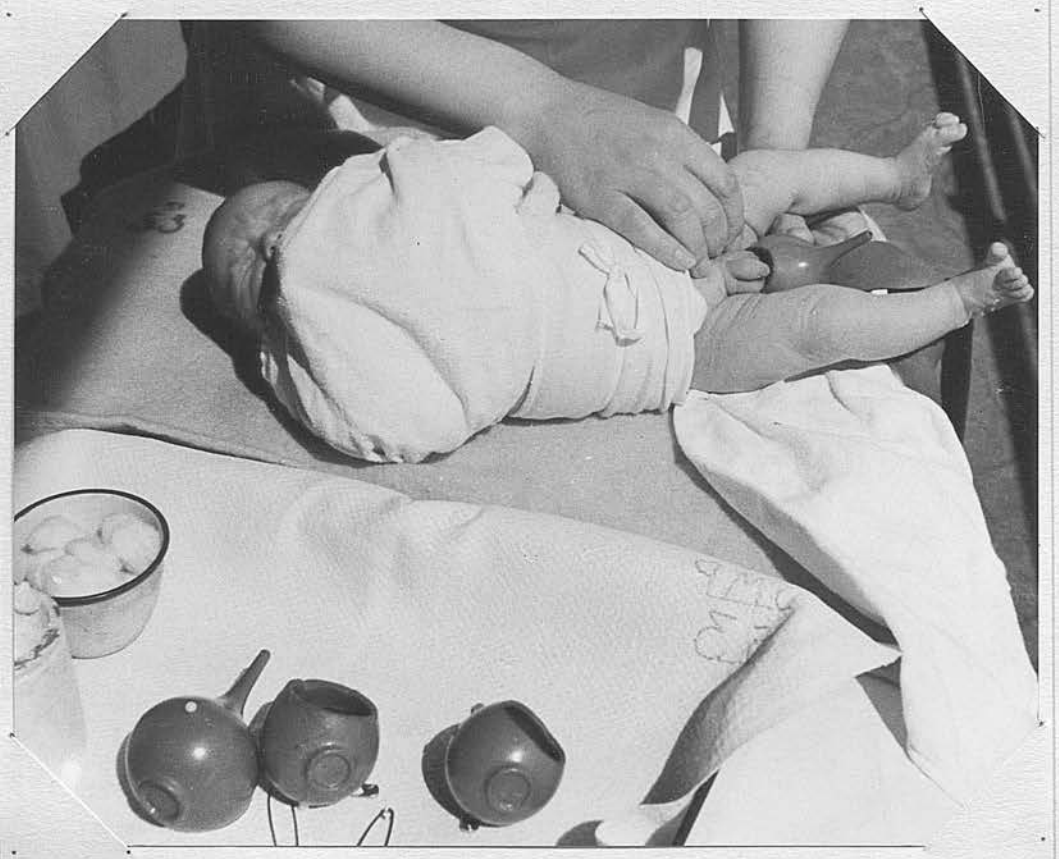
rubber straps, sterile vaseline and safety pins com-:plete the tray so far as fitting the urinal is con-:cerned. The other apparatus shown in the photograph is the electrical signalling apparatus and the collec-:ting vessel referred to in a subsequent section of this paper.

The infant/

The infant is placed on its back on a table and if it be restless, which is not frequent, its arms are pinioned. Nurse then makes sure that the whole of the external genital region is clean and dry, and having done so, smears the thinnest possible layer of sterile vaseline round the part. This, it has been

found, prevents skin abrasion. It must not be forgott-:en, however, and, indeed, its action will not let you forget, that grease is a rubber solvent. For this reason, as little vaseline as possible should be used, otherwise the rubber will soon become unduly soft and the aperture through which the penis and scrotum pass, too big so that it can no longer be accurately fitted to any infant. On no account may baby powder be used.

Nurse /



Applying the urinal. Note the three syringes on the tray. The middle one shows lipping or splaying out of the rubber at the margin of the aperture. This is due partly to the action of urine, but mostly to the vaseline, mentioned in the text. Such a used urinal cannot be relied upon not to leak. It was placed upon the tray to be intentionally included in the photograph, and so illustrate the point mentioned.

Nurse now slips both scrotum and penis into the inside of the syringe, noting at the same time to keep the syringe exit pointing antero-laterally to the infant.

Having /

Having noted that the syringe is a well fitting one, nurse now proceeds to pin the front ends of the rubber straps to the infant's binder. This latter must be fairly firm and not likely to slip down as otherwise the syringe would fall away from the genit-:alia with considerable loss of urine as a result.

If one cannot trust to the binder, it is wise to extend the length of the rubber straps so that they can pass right over the shoulders to be fastened to the binder behind as well as in front. If this is done care must be taken to see that the two straps cross each other after going over the shoulders, so that the strap which was fastened to the left hand side of the binder in front, will be fastened to the right hand side of the binder behind, and vice versa with the other strap. Thus any downward sagging of the binder is counteracted by an upward pull.

When inserting the anterior pins, it is essent-:ial to keep the urinal well forward and upward in re-:lation to the symphysis pubis. This is necessary so that at the next stage in which the infant is turned

over for the insertion of the pins through the straps and binder posteriorly, the tightening of the straps will not pull the urinal backwards over the anus. There should be plenty of clearance as the photograph demonstrates. With the posterior pins inserted the infant is now ready to be returned to its cot.

It may be laid on either side or on its back. It has been my practice to lay the infant on one or other side. The urinal is then adjusted by swivelling it on the stud so that its exit is pointing in a down-

downward direction. This is an important point which all nurses do not appreciate:- some definitely seem to be of the opinion that water can run uphill. To help drainage, one may now tilt the cot a little to the one side.

A piece of rubber tubing is now attached to the exit from the urinal and connected up to a receiving vessel placed at the cot side. In its simplest form this latter consists of a test tube of a suitable size held in a clamp on a retort stand. A two holed rubber stopper provides an entrance for the rubber tube carrying the urine and an exit for displaced air.

The test tube should be adjusted to such a height as will permit of the use of the shortest poss-:ible length of rubber tubing. This is important for two reasons:-

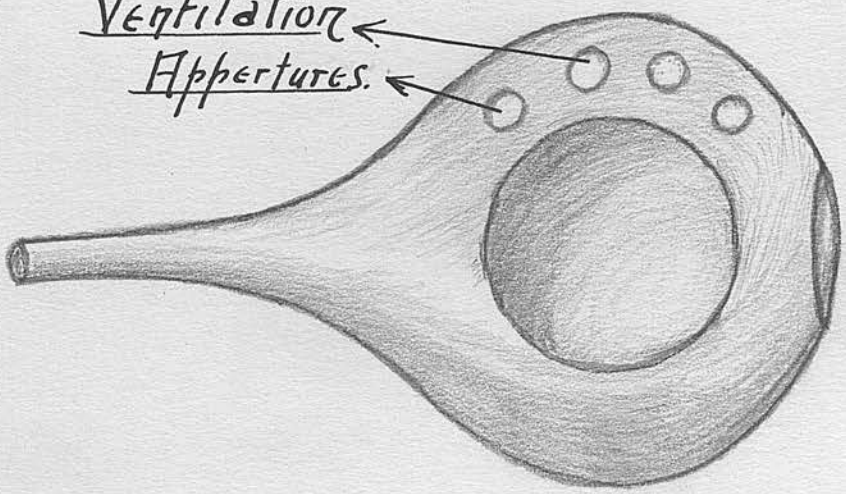
(1) In view of the small amounts of the urine passed at one time, it is essential that the surface area to be wetted by the urine shall be as small as possible.

(2) If the tube is too long there is a very great risk of blockage by kinking: some nurses do not pay attention to this important point. It is wise also, if possible to use a fairly thick walled tube so that it will not be blocked by pressure of the cot blanket, or, perchance, the infant's leg.

The usual napkin can be placed beneath the in-:fant and fastened loosely about it. There is no need for restraint of any kind in these new born infants. The infant can now have its usual covering of cot blanket etc..

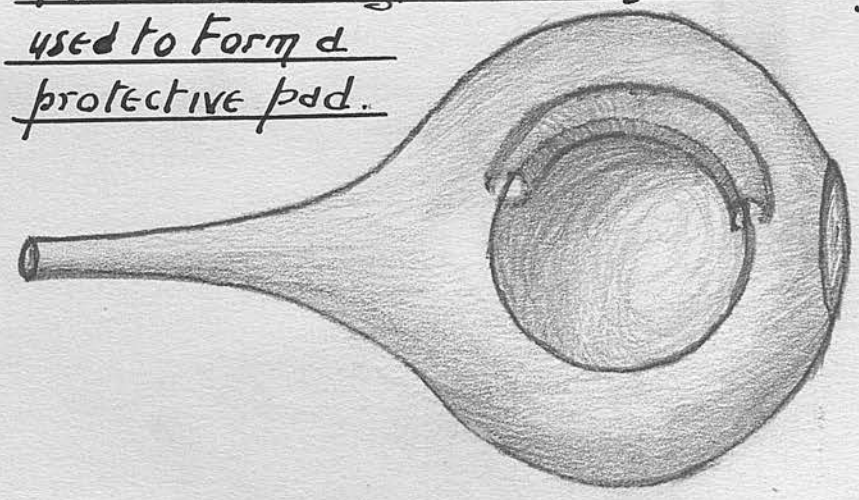
Adaptation For Female.

1st Attempt.



2nd Attempt.

Rubber Tubing. slit Longitudinally used to Form a protective pad.



APPLICATION OF URINAL TO THE FEMALE.

Having satisfactorily solved the problem in the case of new born male infants, attention was next focussed upon the female. It was found that the same appliance may be used, though it must be much more carefully fitted and adjusted to the vulva. In my first attempt to fit this appliance to the female, the hole cut out in the syringe was a very exact fit and just covered the vulva. Moreover, I used a smaller syringe, size No. 4. It was not a success. It acted as a suction cup and caused considerable oedema of the vulva with a pressure mark where the edge of the apperture came in contact with the child's skin. This occurred in a matter of two hours. I attempted to overcome this difficulty by making four perforations $\frac{1}{8}$" diameter and an $\frac{1}{8}$" from the edge of the aperture on its superior aspect, or upper margin. Such ventilation, however, made but little difference. Next I enlarged the aperture somewhat and padded the edge by taking a piece of soft rubber tubing, external diameter 8 mm., internal diameter 5 mm., slitting it up one side, and sewing the edge of the aperture inside the rubber tubing. This was an improvement since it caused /

caused no irritation and no oedema. It was, however, not so well fitting and was apt to leak. Neither was it so readily sterilisable. It seemed as if the trouble was due to using a syringe of too small a capacity, and so a new appliance was made, using a No. 5 syringe and without the padding. This appliance was kept on the same female infant for four consecut--ive days without harm to the infant and without leakage.

I was now in possession of an appliance which I could keep fixed upon an infant for four or five days on end.

COMMENTARY. /

COMMENTARY.

The evolution of this new technique in the collection of specimens of urine from infants, has passed through phases which bear a strong resemblance to the methods of earlier investigations which are described in Section 1. First, the test tube advocated as far back as 1883 by Raudnitz. Second, the teat and bottle as suggested by Pollak (1869) and Epstein. Thirdly, the idea of the separation collecting vessel for the urine introduced by Bendix in 1896, when he devised the first metabolism bed for infants. Fourth, the abandonment of the test tube method for the soft ball method, similar to that of Schabad (1907), itself an evolution of the condom and rubber bag technique of Martin and Ruge et. al. (1876). Schabad had not suggested the method for females. McBride (1927) did, however, only his urinal was made of glass. Ruh (1917) suggested the uses of the ear syringe for females but his technique is not the same; he leaves sharp edges of rubber to injure skin; he uses sticking plaster to fasten it on with. Apart from causing additional injury to the skin, this method undoubtedly would lead to leakage.

SUMMARY. /

SUMMARY.

1. An entirely new method of collecting 24-hour specimens of urine from infants is described in detail.

2. It is efficient and in contradistinction to all previous apparatus specially devised for the purpose,

3. It is cheap,

4. It is easily made,

5. It is easily procurable.

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S E C T I O N . III.

AN ELECTRICAL DEVICE TO SIGNAL WHEN

URINE IS PASSED.

INTRODUCTION.

It occurred to me that if one could learn the length of intervals of time at which the infant was likely to pass urine - that implies having some means of knowing when urine was passed - then, it would be possible to remove the urinal, described in the previous section, from the infant immediately urine had been passed and keep it off for a period of time less than that interval, so as it were, to rest the infant from the constant wear of the appliance.

By adopting this technique, I hoped to be able to collect the urine for the whole period of the infant's stay in hospital. I felt that this resting of the infant was important in preventing any possible skin trauma and in giving the infant periods of absolute freedom.

I therefore determined to so arrange matters that on the passage of urine an electrical circuit would be automatically closed and cause a bell to ring.

This piece of apparatus is additional to the urinal described in the previous section, and which is all I had originally contemplated making. It is not, strictly speaking, necessary for the collection of a twenty-four hour specimen of urine, but rather for the collection of specimens of urine passed at one voiding. Neither can it be said to be cheap or unbreakable, though it is simple for any mechanically-minded person to work. I would emphasise that it was made before the survey of the literature given in Section IV was undertaken.

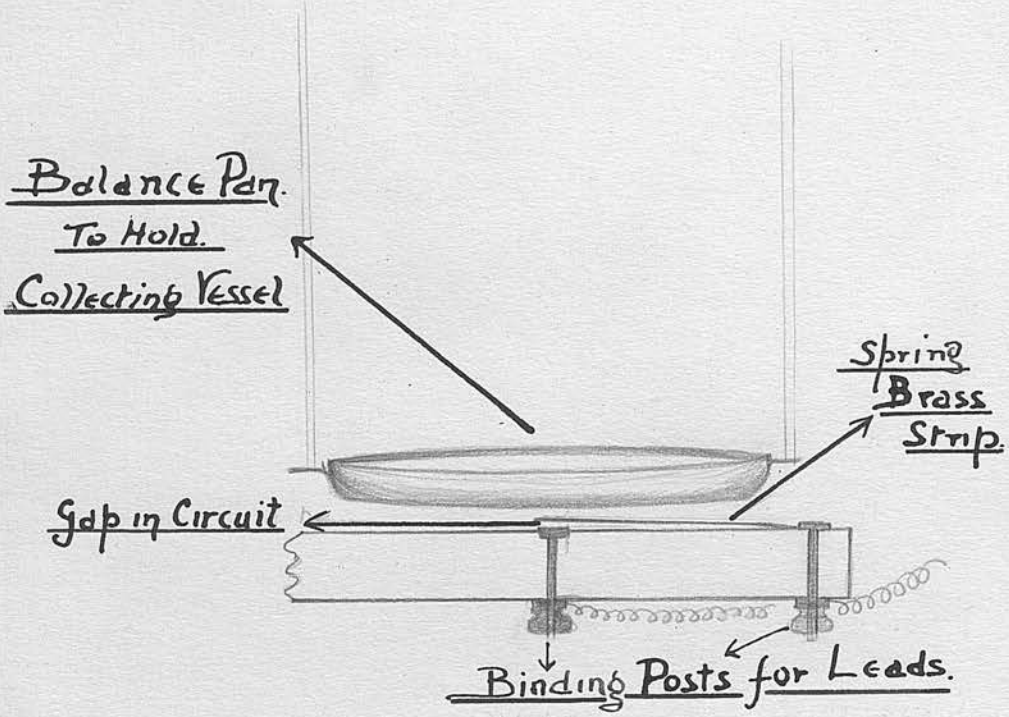
EVOLUTION OF THE APPARATUS.

At the commencement of my attempts to make the necessary piece of apparatus, I laid down certain features which I felt it to be necessary that the apparatus should possess.

These were:-

1. An intelligent nurse should be able to work it.
2. It must be sterilisable and easily kept clean.
3. It must be simple in construction.
4. No electrical current must be allowed to come into contact with the urine, since this would to some extent, alter the chemical and physical characteristics of the urine.
5. It should not be worked off the electrical main supply.
6. It must work on the passage of $2\frac{1}{2}$ - 3 ccs. of urine.

On turning the problem over in my mind and giving due consideration to the various means by which an electrical circuit may be closed, e.g. (1) the pull of gravity /



Sketch to illustrate proposed Method of using a Beam Balance to close the electrical circuit.

gravity on a weight; (2) Buoyancy of a float in water: (3) A make and break contact: (4) The use of a mercury key. I decided that there were three methods by which I might achieve my object:-

1. By the use of a balance.
2. By the use of a float.
3. By a combination of these two methods.

1. The Balance Method.

This method is simple and there are two varieties of it to each of which I gave consideration.

A. The first consisted in using an ordinary beam balance, on one pan of which is placed the collect--ing vessel, and on the other, weights to exactly counter-balance it. The discharging end of the rubber tube connected to the ear syringe is fixed above the collecting vessel in such a way that it does not inter--fere with the free working of the balance, but does discharge urine into the vessel on the balance pan. The two leads of the bell circuit are now placed in position beneath the pan of the balance containing the collecting vessel, so that when the pan comes down upon them, the electrical circuit is closed. If the balance is reasonably delicate at all, immediately a few drops of urine are discharged from the rubber tube into /

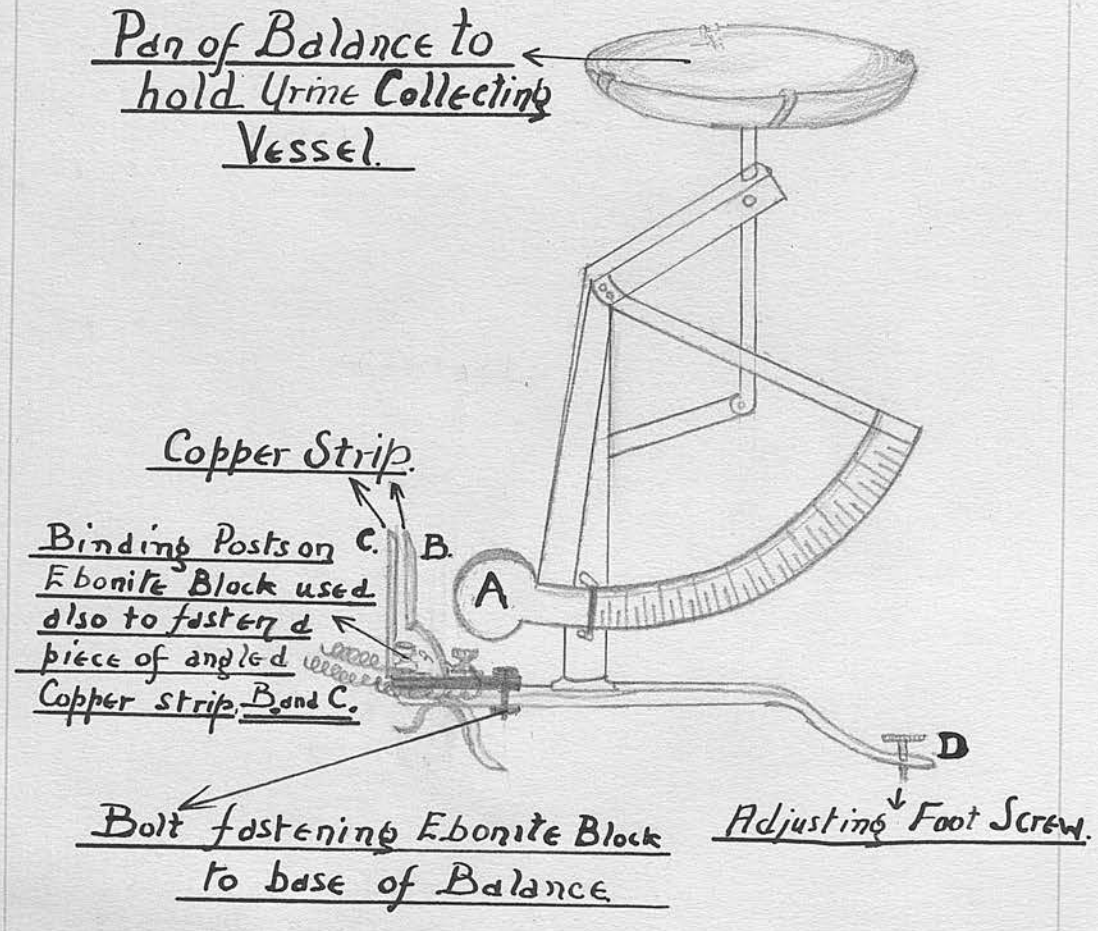
into the collecting vessel the pan would readily drop to cause the bell to ring.

This apparatus satisfied all the desiderata which I had in mind except that:-

1. A nurse could not be relied upon to work it.
2. It would be a cumbersome apparatus to stand at a cot-side.
3. It might be too delicately balanced and mere vibration, or slight current of air, or perhaps the opening and shutting of the nursery swing door would cause it to work when no urine had been passed.
4. It might be too indelicately balanced so that on the passage of urine it would fail to work.
5. The price of a balance was more than I could afford.

This apparatus I never actually constructed, though I made drawings of it. The proposed position of the electrical contact is shown in the sketch, page 121.

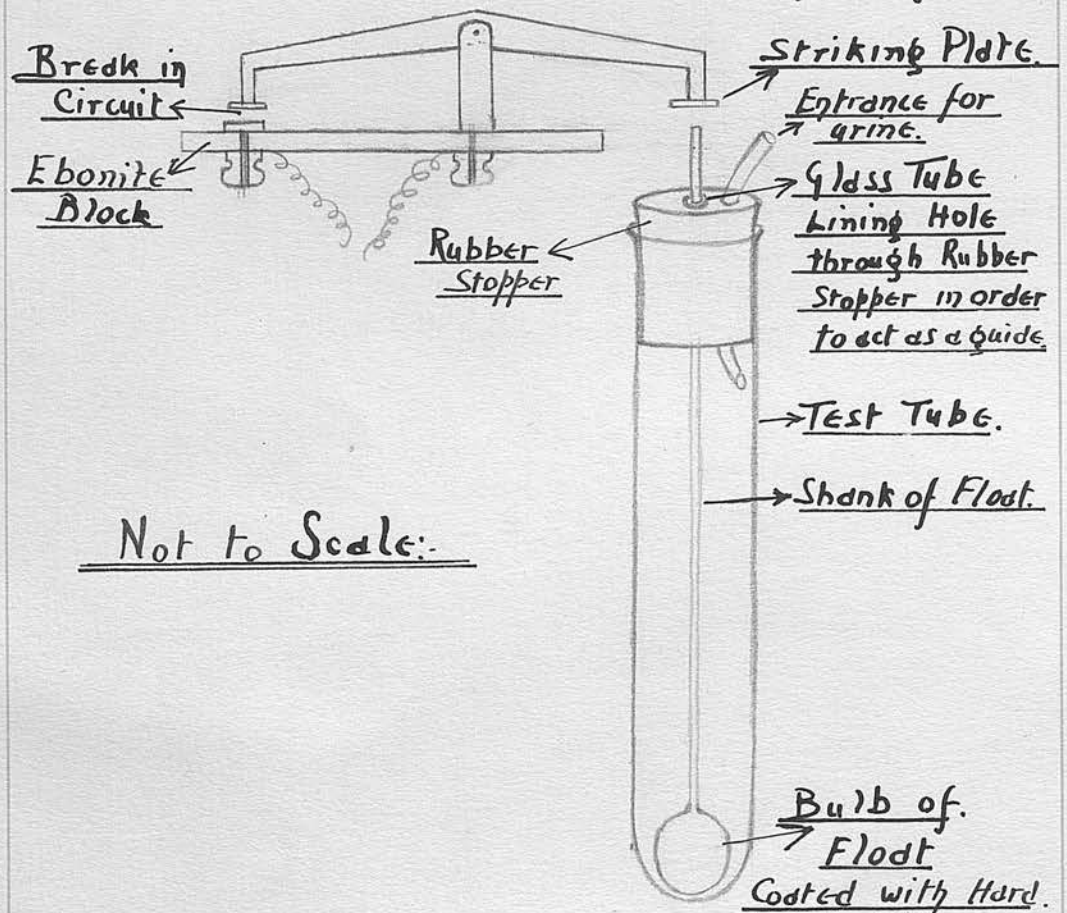
B. The second makes use of a cheaper type of balance, one commonly used for letter weighing and even more delicate estimations as e.g. weighing of guinea-pigs. The sketch shows clearly the arrange-
-ment /


Pan of Balance to hold Urine Collecting Vessel.
Copper Strip.
Binding Posts on Ebonite Block used also to fasten a piece of angled Copper strip, B and C.
C.
B.
A
D
Bolt fastening Ebonite Block to base of Balance
Adjusting Foot Screw.

arrangement of the contacts and the method of working. Investigation made with such a balance soon demonstrat--ed, however, that (1) it was not nearly delicate enough in its action, (2) that it could not be depend--ed upon to work with a load of 2-3 cc., and, (3) that it would probably require too much skill on the part of a nurse to adjust the balance each time. Adjust--ment was to be made by first placing the receiving vessel on the pan of the balance and then adding weights, small lead shot, or metal fillings, to bring the end of the arm A against copper strip B which would be separated from copper strip C by just a hair's breadth. The adjusting foot screw D would also have been used in this operation. (see sketch page 124.)

2. Float with Balance.

The first apparatus which I did actually construct was a combination of both balance and float principles. The idea came to me when, in search of inspiration, I went to the Museum in Chambers Street and, there, was much struck by the delicacy of movement displayed by the balance wheel of a watch. The principle was, that on the introduction of urine into a collecting vessel, a glass float previously placed there, would rise. /



Both pieces of apparatus were held in clamps on a retort stand and properly adjusted to each other.

rise. In rising the float would strike against and raise one arm of a balance held above it, while the other arm came into contact with one of the leads of the bell circuit, the balance arm itself being the remaining electric lead. Thus the bell circuit would be closed and the bell ring. This was actually achieved in an experimental apparatus which, however, never left the experimental bench since it did not appear to be a practicable proposition for introduct-ion to a nursery. (see sketch page 126.)

Certain difficulties had to be overcome, however:- (1) This apparatus must work on the introduction of $2\frac{1}{2}$ to 3 cc. of urine into the collecting chamber. That is, the float and the vessel containing it had their relative sizes determined by this requirement. For a float, I used a capillary tube, on one end of which there was blown a bulb, the other end of the tube being sealed. The bulb and tube were together about $6\frac{1}{2}$" long. This float I found would rise from $\frac{1}{4}$" to $\frac{3}{8}$" inside a $\frac{5}{8}$" test tube on the introduction of $2\frac{1}{2}$ to 3 cc. of water. The capillary action, however, which existed between the outside of the float and the inside of the test tube was, to say the least of it, exceedingly fierce, and nearly always interfered with /

with the working of the float. This most troublesome defect was at last overcome by coating the outside of the bulb of the float with hard paraffin wax.

(2) In rising, the float was frequently apt to miss the balance arm suspended above it owing to it not being sufficiently well guided. To overcome this there was inserted into the mouth of the collecting vessel a two-holed rubber stopper. A glass tube of a bore just large enough to allow the fine shank of the float to pass through was inserted into the rubber stopper. This acted as a satisfactory guide. The other hole was, of course, for the entrance of urine.

(3) In order to accommodate not only the minimum quantity of urine, namely, $2\frac{1}{2}$ cc., but also the maximum quantity which I expected the infant to pass at one time, say, 60 cc., using a test tube of $\frac{5}{8}$" bore I found that I would need a test tube 15" or more in length, and that I would require my float to have a shank of a corresponding length. This long fine shank would be much too fragile a piece of apparatus, however: it would be readily broken, even in normally striking against the balance arm suspended above it. Some other means must be found in order to work the bell signal reliably, and so I set about the making of a third apparatus.

3. Float Method. /

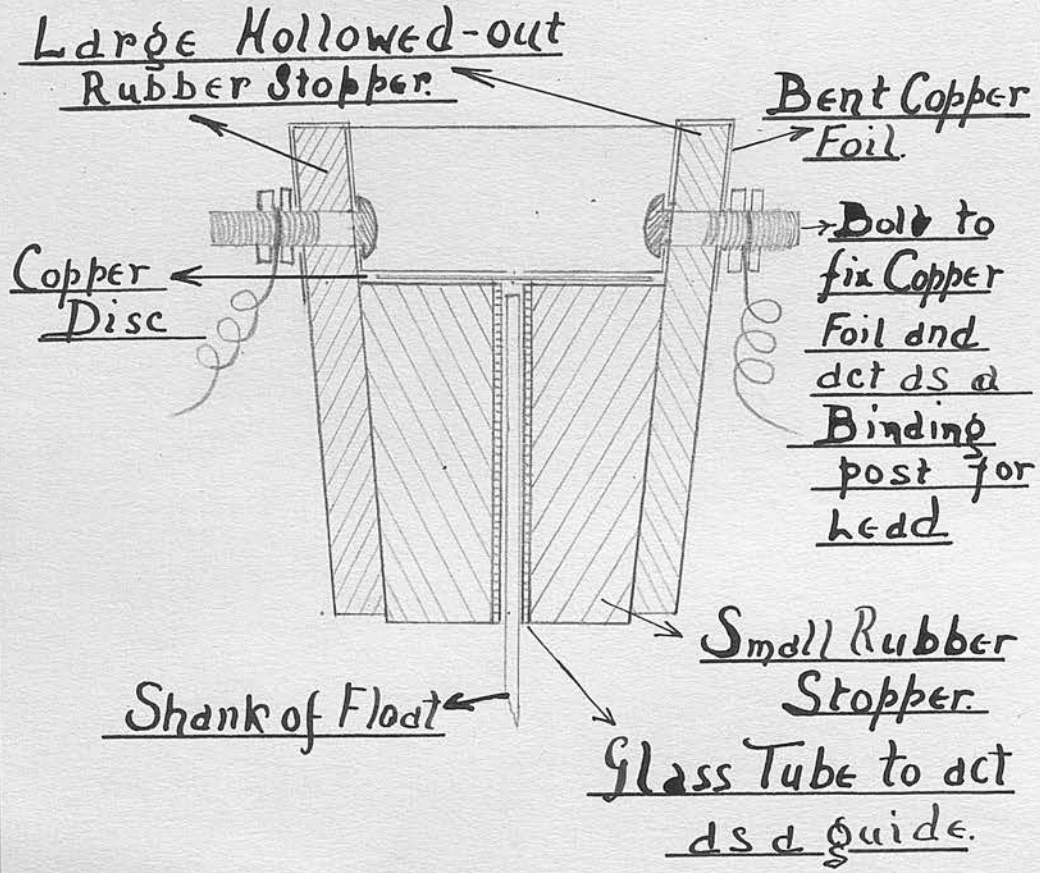
3. Float Method.

In designing this apparatus I kept in mind the defects of the last one and concentrated first on designing a better, simpler and more reliable switch than was provided by a suspended balance arm. I abolished the balance arm and instead endeavoured to incorporate an electrical switch inside a rubber stopper. This was accomplished at first in the following manner:-

The materials required were a rubber stopper $1\frac{1}{4}$" long, diameter at the top $1\frac{1}{8}$", and at bottom $\frac{7}{8}$". A smaller rubber stopper $\frac{7}{8}$" long, diameter at the top $\frac{3}{4}$", and at the bottom $\frac{5}{8}$". Small bore glass tube. Copper foil. 2 small bolts, $\frac{3}{4}$" long by 3/32" diameter and equipped with 2 nuts and washers. These were assembled as follows:- The piece of glass tubing of a bore sufficient to act as a guide to the shank of the float was passed through the centre of the smaller stopper, and cut off flush at either end. The larger stopper was hollowed out sufficiently to permit of the smaller stopper being passed into it and partially through it so that there was a space fully $\frac{3}{8}$" deep inside the larger stopper and above the smaller. A copper disc, $\frac{5}{8}$" diameter was now laid horizontally /

Design of First Switch.

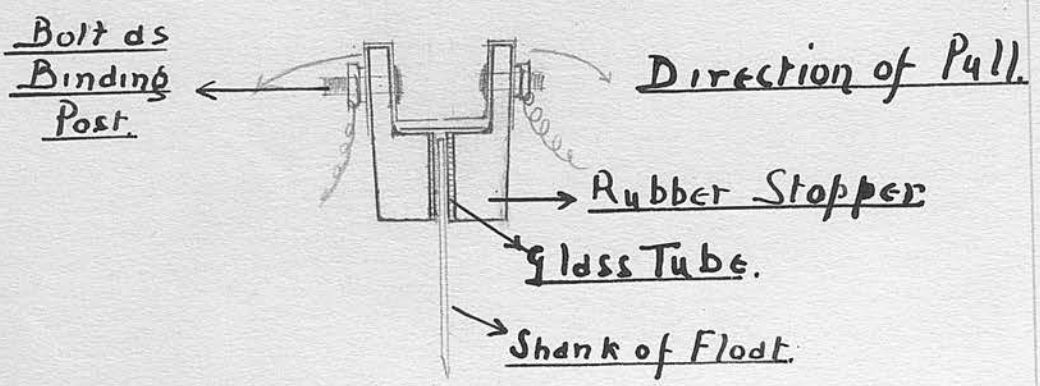
Double Actual Size

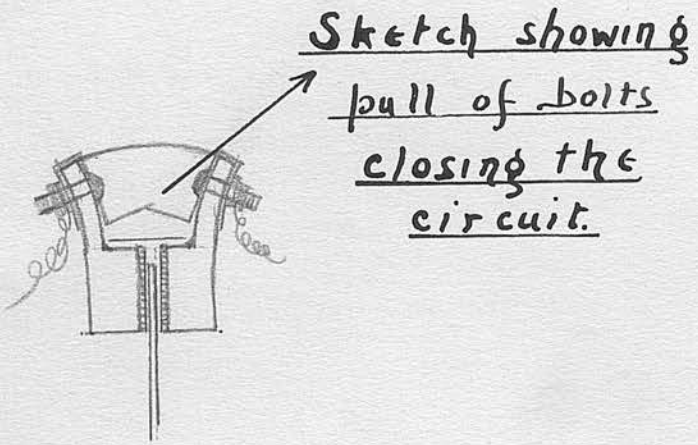


horiztonally at the foot of this space. Two holes were pierced in the sides of the larger stopper $\frac{1}{4}$" from its upper margin and diametrically opposite to each other. Two pieces of copper foil, size $1\frac{1}{2}$" x 7/16" were cut and each was bent and fixed in position over the upper edge of the larger stopper by the small bolt which passed through the copper foil both on the inner and the outer aspects of the stopper as well as through the hole previously made in the stopper. The inner ends of the copper foil were bent at right angles to the almost vertical side of the stopper and each was in the same horizontal plane as its opposite neighbour. Between the two there was a gap 1/16" wide. This gap, when closed by the copper disc beneath it being pushed up by the float, constituted a switch which completed the bell circuit. The two bell leads were attached one to each of the two bolts already mentioned. On trial this switch functioned fairly well. It was, however, big and clumsy and made the test tube beneath it look top heavy. It was most inelegant. The next step was to make this switch of a size suitable to insert into a $\frac{5}{8}$" test tube.

This was accomplished in the first instance by using /

Sketches To Show Effect of Weight of Bolts.



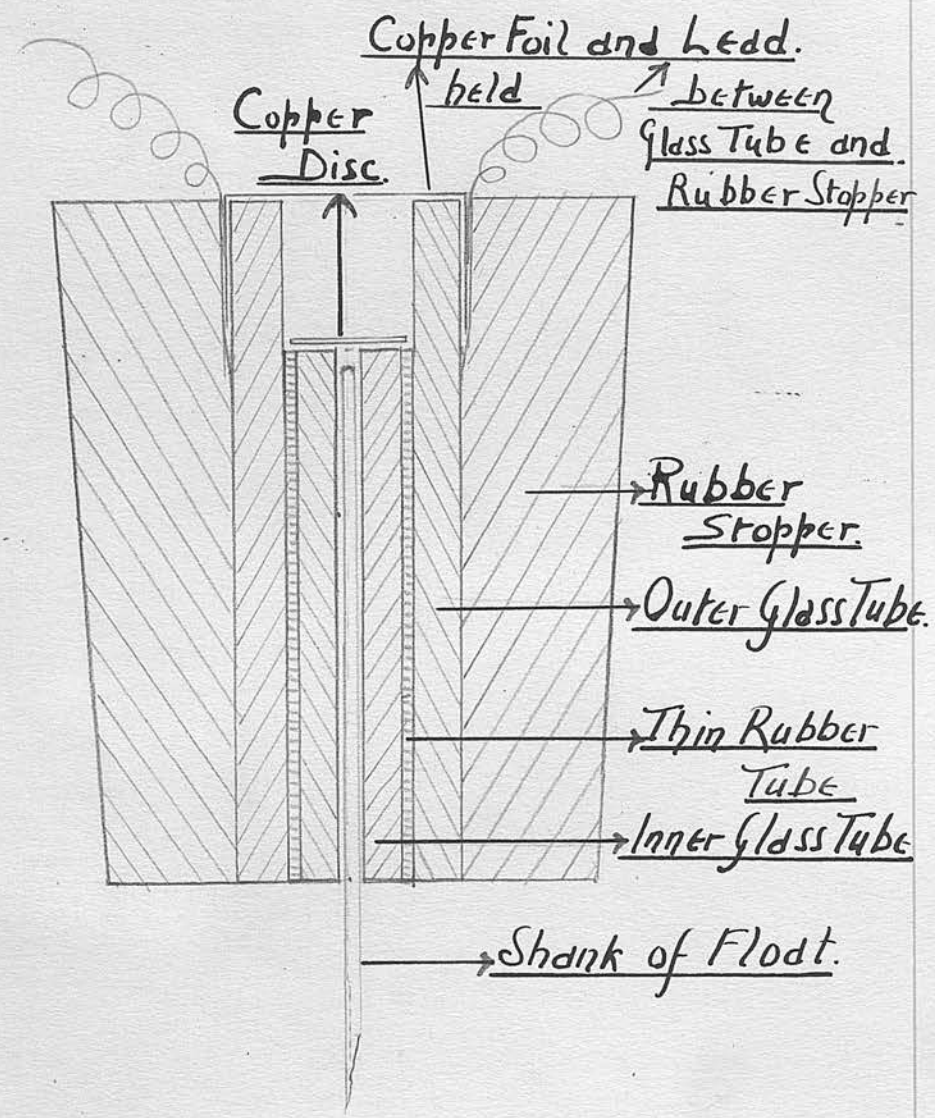


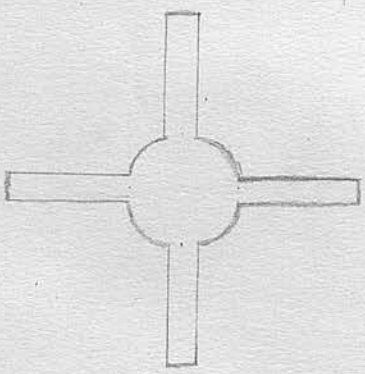
using a stopper to fit a $\frac{5}{8}$" test tube. The upper half of it was hollowed out so that the walls of the cavity thus created were about 1/10th" thick. Through the centre of the lower part a hole was pierced to accommodate the glass tube to guide the float stem. The upper part of the stopper was fitted with copper foil in the same way as the previous switch, the only difference being that it was on a smaller scale. The same size of bolts were used. This switch did not function so well because the thin upper wall of the rubber stopper was pulled outwards by the weight of the small bolts used and by the pull of the electric leads. This resulted in the copper disc not always being able, though raised by the float, to close the gap, while sometimes the gap was closed accidentally as shown by the sketch. It was essential for good functioning to relieve this strain, and this was accomplished in making the next switch.

It was made from:- a stopper to fit a $\frac{5}{8}$" test tube, some glass tubing, rubber tubing, and copper foil.

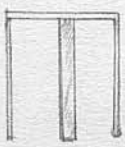
First. A piece of glass tubing of a bore sufficient to accommodate the stem of the float and about 3/16" shorter than the stopper was closely invested with a piece of rubber tubing of the same length. /

Design of Second Switch Enlarged Four Times





Shape to which Copper Disc was cut



Copper Disc on legs.

length. This, in turn, was fitted very accurately inside a piece of glass tubing 3/16" longer than the first piece, and so that all three were flush at one end. Now these were fitted into a hole through the centre of the rubber stopper so that they were all flush with the lower end of it. A copper disc was laid on top of the inner glass and rubber tube. Two pieces of copper foil strip $\frac{1}{8}$" wide were now cut. One end of each was held firmly between the rubber stopper and the outer glass tube, and each was diametrically opposite to the other. The free ends were bent at right angles towards each other but with a gap 1/16" between them. The ends of the electric leads were inserted between the rubber stopper and the outer glass tube one in contact with each piece of copper foil. This switch acted on the same principle as the previous one, but it had one defect. The copper disc on being raised did not always rise all in the same plane horizontally; so it did not always close the switch gap. To remedy this, it was necessary to make a guide for the disc. This was done by putting the disc on four legs, so that each leg was quarter of the way round the circumference of the disc from its neighbour, (see sketch). It was not unlike a miniature four-legged stool. The legs were in loose contact /

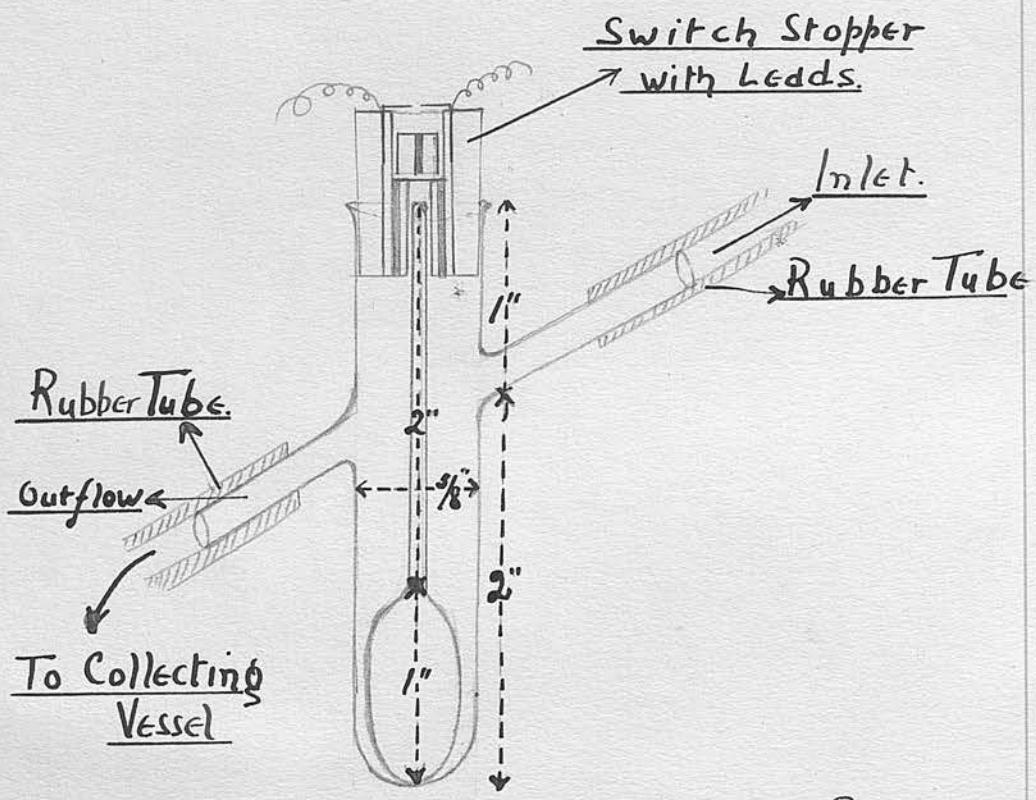
contact with the inner wall of the glass tube and this prevented the disc from tilting too much. This was a reliable switch.

Having now perfected the switch, I gave my attention to the problem set by the fact that the switch was to be operated by a float rising in a vary--ing volume of fluid. A little reflection showed that there was only one way towards a solution. The volume of fluid acting on the float must not be allowed to vary. In other words, the float must work in a chamber which would hold a constant quantity of fluid only, and that quantity must be from $2\frac{1}{2}$ cc. to 3 cc. It would be wise then to standardise the float and the chamber as one unit which would allow any excess over 3 cc. to by-pass it into a collecting vessel.

I had made for me - for, on trying, I found that for technical reasons I was unable to make it myself - a float chamber containing a standard sized float. This chamber is a tube $\frac{5}{8}$" in diameter and 3" long, closed at one end. At about 2" from the bottom there is, on the one side, an inlet tube to which is attached the rubber tube from the ear syringe. Opposite to it, and slightly lower, is an outlet tube which is about

a /

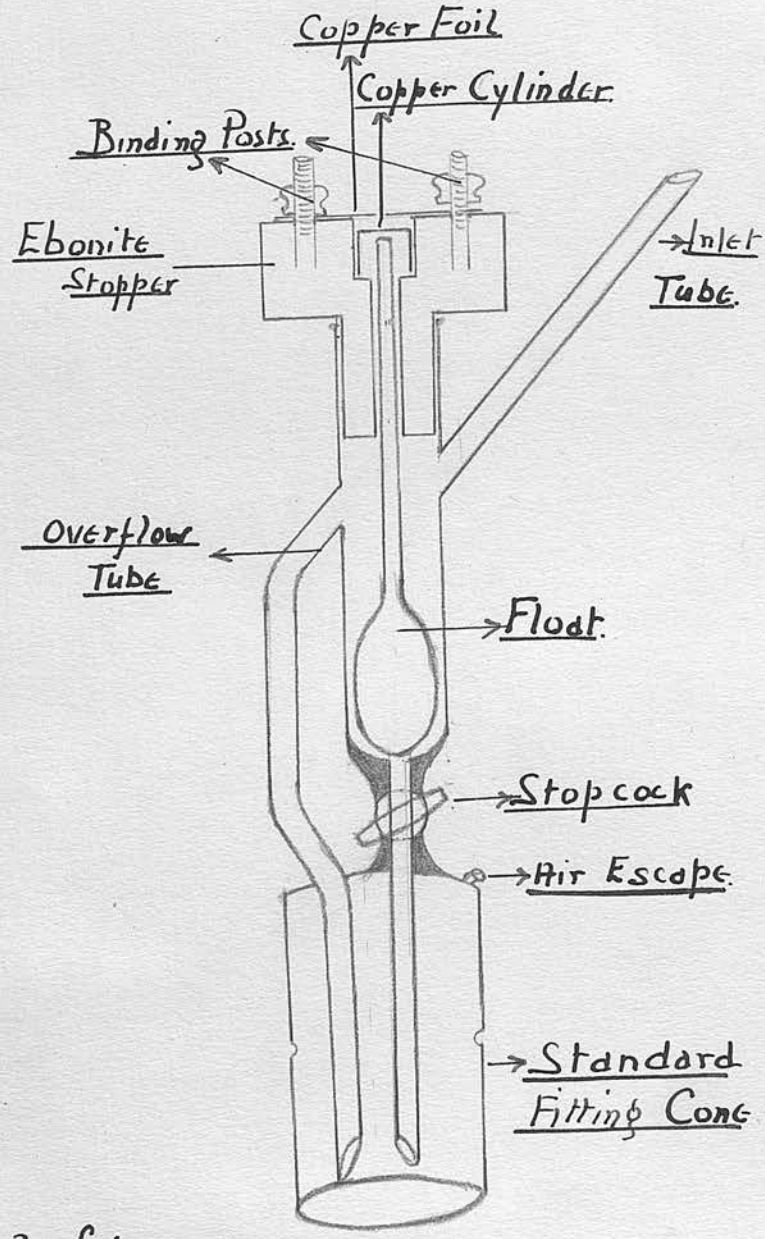
Section Drawing of First Apparatus used at Cot-side.



Actual Size.

a 1/16" larger bore than the inlet. From the outlet a rubber tube leads to the collecting vessel. The float having a bulb about 1" long and a stem about 2" long is placed vertically in the chamber so that the top end of the stem is engaged in the glass guide tube of the stopper switch which is inserted in the open upper end of the chamber. This apparatus was now tried out at the cot-side in hospital and was a most dramat--ic success. The bell rang when urine was passed and continued to ring until nurse went in and tilted the float chamber to empty it out into the collecting vessel. When at the cot-side, the float chamber and the collecting vessel were held in place by clamps on a retort stand. To the base of the latter a bell and battery were fixed. The whole apparatus could be lifted in one hand, using the upright of the retort stand to grasp it by.

Thus far my expenditure in making this apparatus had been kept to the very minimum, for I had little money to spare. My outlays had not reached 15/- so far, and the most expensive item was 2/9 for the float chamber, which I had had made for the purpose. I now felt justified, however, in spending a little more money /

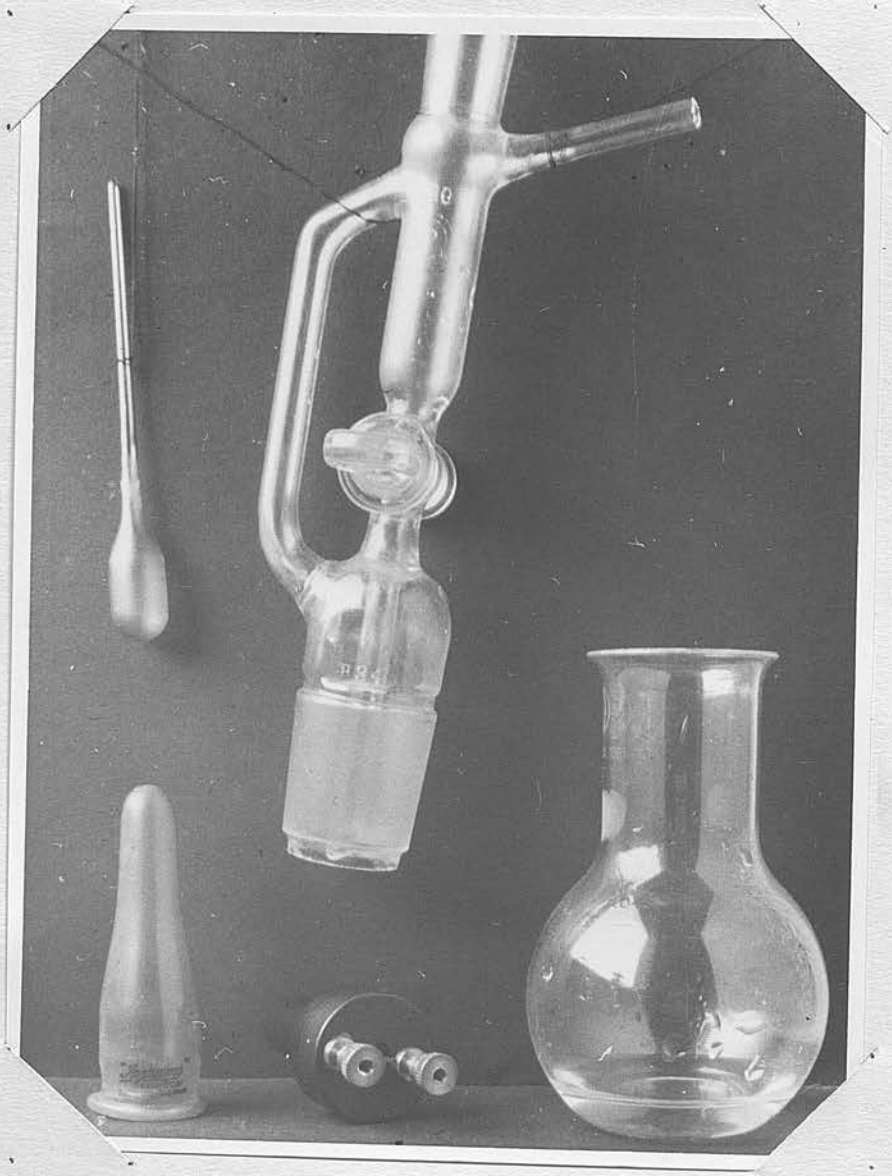

Copper Foil
Copper Cylinder
Binding Posts
Ebonite Stopper
Inlet Tube
Overflow Tube
Float
Stopcock
Air Escape
Standard Fitting Cone

Actual Size

money in having the apparatus made accurately and neatly by a skilled workman. For this purpose I communicated with Messrs. Quickfit & Quartz, Triplex Works, Kings Norton, Birmingham. They were very sympathetic, understood my requirements and quoted me prices. I had the stopper switch made of ebonite and not rubber, for rubber is affected by the presence of urine and is apt to swell up. The float chamber I had made of Pyrex Glass for strength, and it was made exactly as that already described, except that at the lower end of the chamber I had a stop-cock placed. This served to empty the float chamber, allow the float to fall and so stop the bell from ringing. In effect, it transformed the whole apparatus into a sort of two-way on and off bell switch; the on switch being worked by the infant on passing urine and the off switch by the nurse on emptying the float chamber by opening the stop-cock. The stop-cock, of course, must be closed once the float chamber is properly drained in order that the apparatus may be reset.

DESCRIPTION /

APPARATUS. Unassembled.



FLOAT.

Float Chamber.

Lamb's Teat.

used as a dust excluder.

Ebonite Stopper with binding posts and copper foil strips.

$C O_2$ Flask. used as a collecting vessel.

DESCRIPTION OF THE APPARATUS AS NOW USED.

The apparatus it will be seen consists of four parts:-

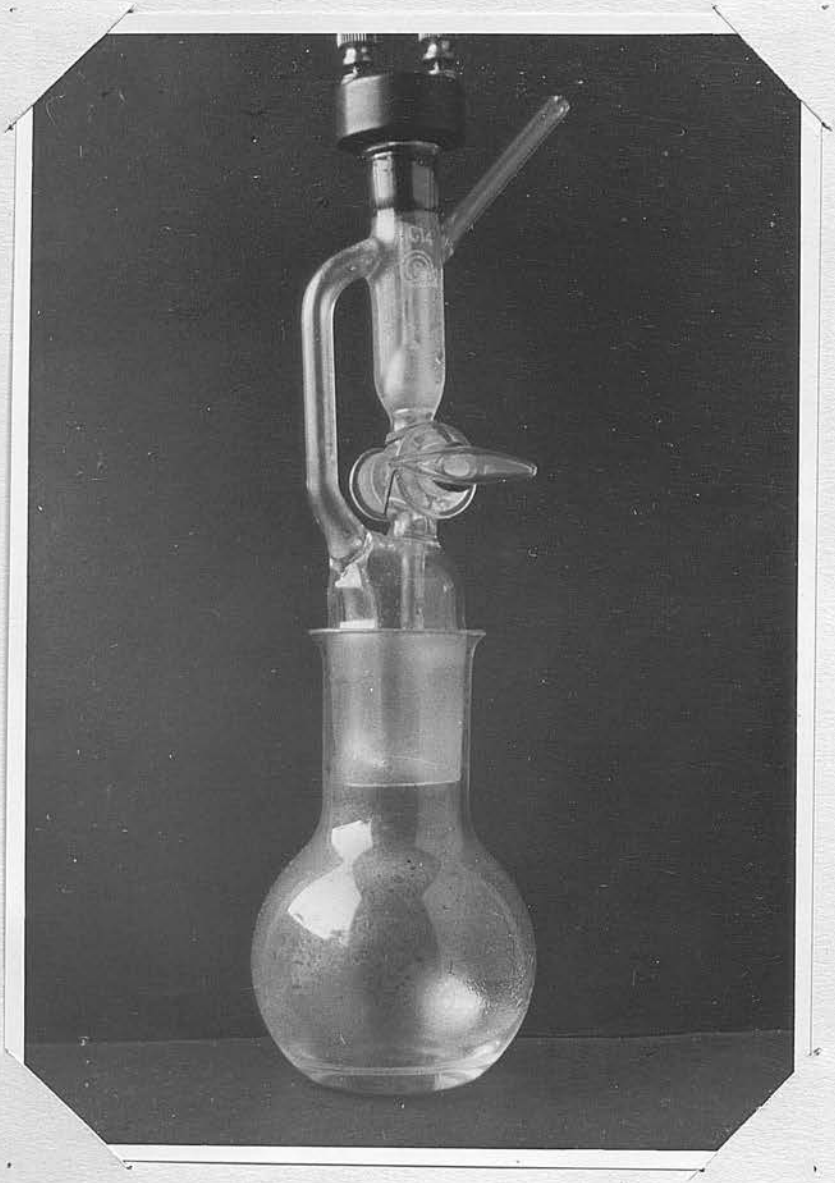
1. What I call a glass float chamber is made of Pyrex Glass. The actual chamber is about $2\frac{1}{4}$" long or deep, and its diameter $\frac{1}{2}$". At its lower end there is a drainage tube which can be opened or closed by a stop-cock. An inlet tube enters the chamber about $1\frac{3}{8}$" from its lower end, while an overflow tube leaves the chamber at a point diametrically opposite the entry of the inlet tube, but $\frac{1}{8}$" lower down. The ends of the overflow tube and the drainage tube are brought near to each other and put within a standard size glass cone, provided with an air escape. This permits of the whole apparatus being used, if so desired, as a stopper for a graduated measuring cylinder, having a standard socket of a similar size. The top of the float chamber is made in the form of a standard fitting socket to accommodate the standard stopper switch.

2. Within the float chamber there is placed a very /

very light bulbous glass float, and having a thin stem or shank of a suitable dimension.

3. Into the top of the float chamber there is fitted an ebonite stopper. It is about 1½" long, and a cylindrical hole ⅛" in diameter has been bored through it vertically. The shank of the float works in this aperture in an up and down direction. The upper end of this aperture is widened out to a diameter of 5/16" and to a depth of 5/16". Thus, a small ledge is formed. Into the aperture so formed, and resting on this ledge there is placed a small and very light copper cylinder. This cylinder is a very exact fit, so that when its closed upper end is lifted by the shank of the float rising beneath it, it rises without being tilted. Two binding posts are fixed into the top of the stopper, and to these the leads of a bell, buzzer and/or light circuit are brought. The binding posts, it will be observed, are diametrically opposite to each other, and to each there has been fixed a very narrow strip of fine copper foil. These strips of foil stretch out towards each other over the top of the copper cylinder already mentioned, but they do not touch each other. They constitute, in other /

APPARATUS. ASSEMBLED.



other words, the break in the electrical circuit, which break is closed by the raising of the copper cylinder from below by the float.

4. The urine collecting vessel. This may assume many forms. Originally I had intended having specially made amber coloured graduated glass cylinders with a standard fitting socket. They were to be costly, however, and I contented myself at first with the use of an ordinary CO_2 flask which fitted the cone fairly well. Later, large test tubes were used and found to be more suitable..

TECHNIQUE.

1. The float chamber containing the float and with the ebonite stopper in position is inserted into the mouth of the collecting vessel, the whole being held rigid by a clamp on a retort stand. The leads of an electrical circuit incorporating some signal, as a bell, are made fast to the binding posts.

2. The urinal is attached to the infant, and a very short rubber tube is used to connect it up to the inlet tube of the float chamber. This latter is, of course, outside but very near to the infant's cot.

3. /

3. The stop-cock at the foot of the float chamber is closed, and the apparatus might be termed to be set ready for action.

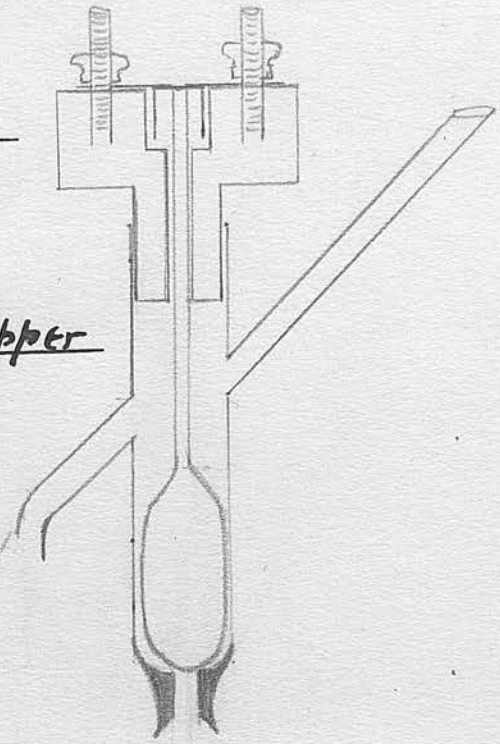
When the infant passes urine, the urine passes via the urinal and rubber tube to the float chamber. The glass float within the chamber rises and in so doing raises the copper cylinder which closes the circuit and so works the signal. If there is more urine than the float chamber will hold, the excess will pass by the overflow tube directly into the collecting vessel. Thus we get over the difficulty of variation in the volume of the urine passed on each occasion. Now, the signal continues in action until the attendant nurse comes, and, by turning the stop-cock, drains the float chamber into the collecting vessel, thus allowing the float and the copper cylinder to fall and so break the circuit. She then closes the stop-cock and the apparatus is reset.

In the course of using the apparatus it was found that the highest degree of reliability was attained if due care and attention was paid to the following points:-

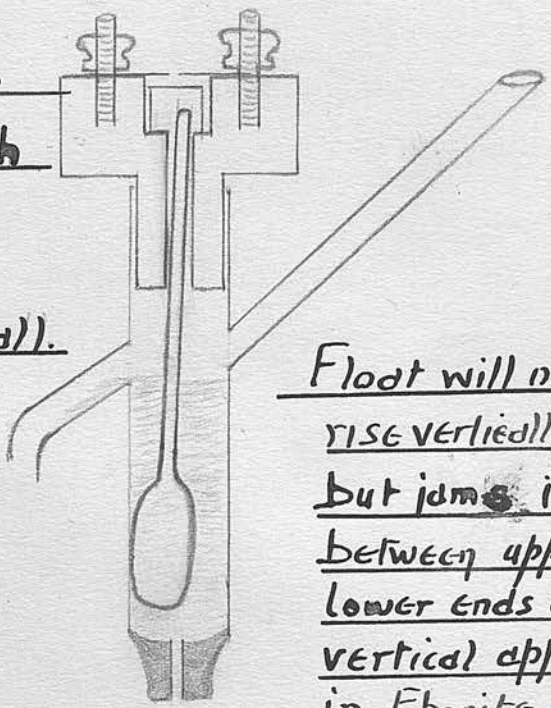
(1) /

Sketch To Show

Float Shank
Too Long
Preventing Stopper
From Entering
Float Chamber
AND ALSO
Closing Electrical
Circuit.



Sketch To Show
Failure of Switch
to work
Cause.
Float too small.
Short Shank
Small Bulb

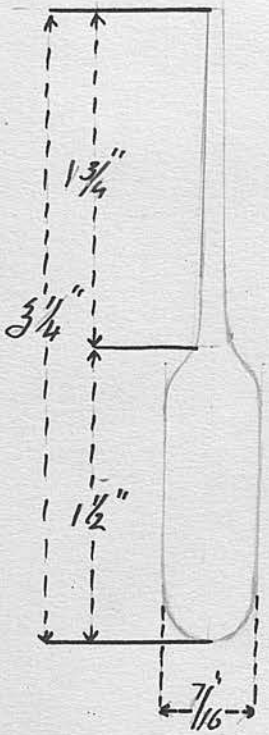


Float will not
rise vertically
but jams itself
between upper and
lower ends of
vertical apperture
in Ebonite
Stopper.

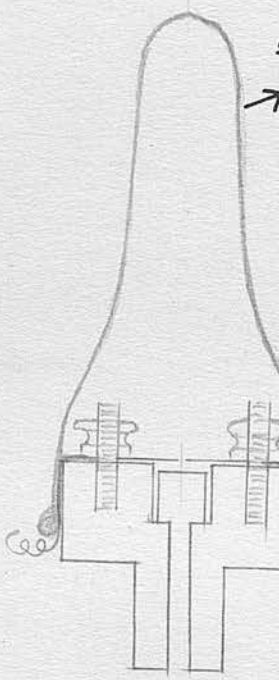
(1) The inlet tube should not be as long as that shown in the sketch. All nurses are not careful and on every one of my pieces of apparatus this tube was snapped off at its junction to the body of the float chamber. I am satisfied that it was due to the use of unnecessary pressure and leverage by the nurse when attaching the rubber tube to the inlet. In having the apparatus repaired - not an easy matter in war-time - I had the inlet tube made much shorter, just enough to slip the rubber tube on to and no more. With this alteration giving a nurse much less leverage to work on, I have so far had no further accidents.

(2) It is essential to coat the bulb of the float with hard paraffin wax. This greatly diminishes the fierce capillary attraction present between the bulb of the float and the side wall of the float chamber.

(3) The total length of the float is a matter of prime importance:- (a) It must not be too long else it will prevent the proper introduction of the switch stopper into the mouth of the float chamber, and also cause the electrical circuit to be closed while one is trying to insert the stopper. (b) It must not be too short as it will then not rise vertically in the ebonite stopper and will jam itself. (c) The optimum length /

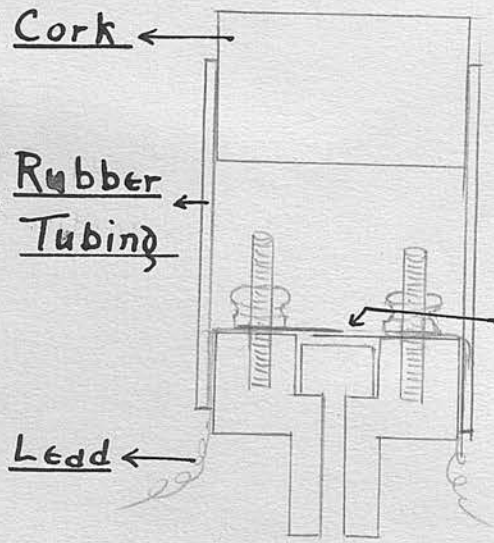


Stock Ampoule used as a Float



Lamb's Teat used as a Dust Excluder.

Lead



Dust Excluder as now used.

Overlapping Copper Strips as now used to close circuit

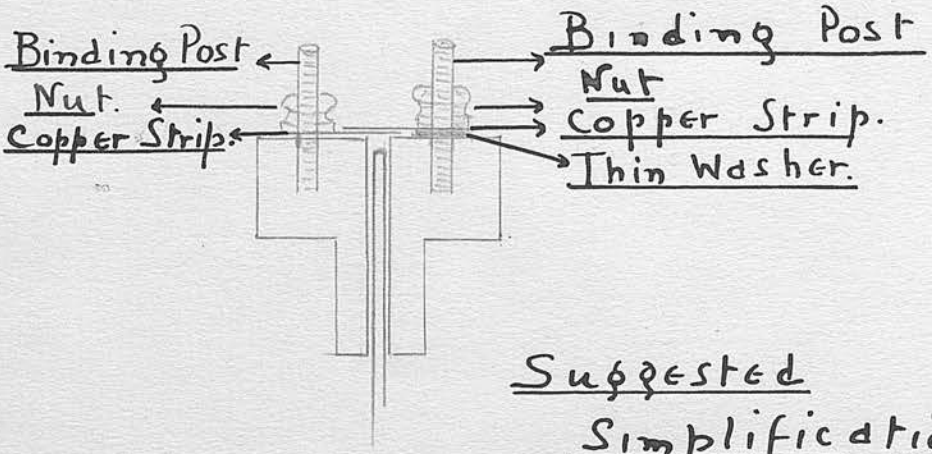
Section Drawings.

length is one which will require a rise of $\frac{1}{8}$" only to close the circuit.

(4) The floats are fragile and inquisitive people who have investigated the apparatus by removing the stopper have frequently smashed the float stem by ramming the stopper in again. Obviously they had not had their curiosity enlightened by their investigations. This mortality among floats was a matter of some concern, for they cost 1/- each. I discovered, how--ever, a cheap source of supply in the shape of unused ampoules with longish stems. The stems I was able to shorten to the accurate size required by using an ordinary bunsen flame.

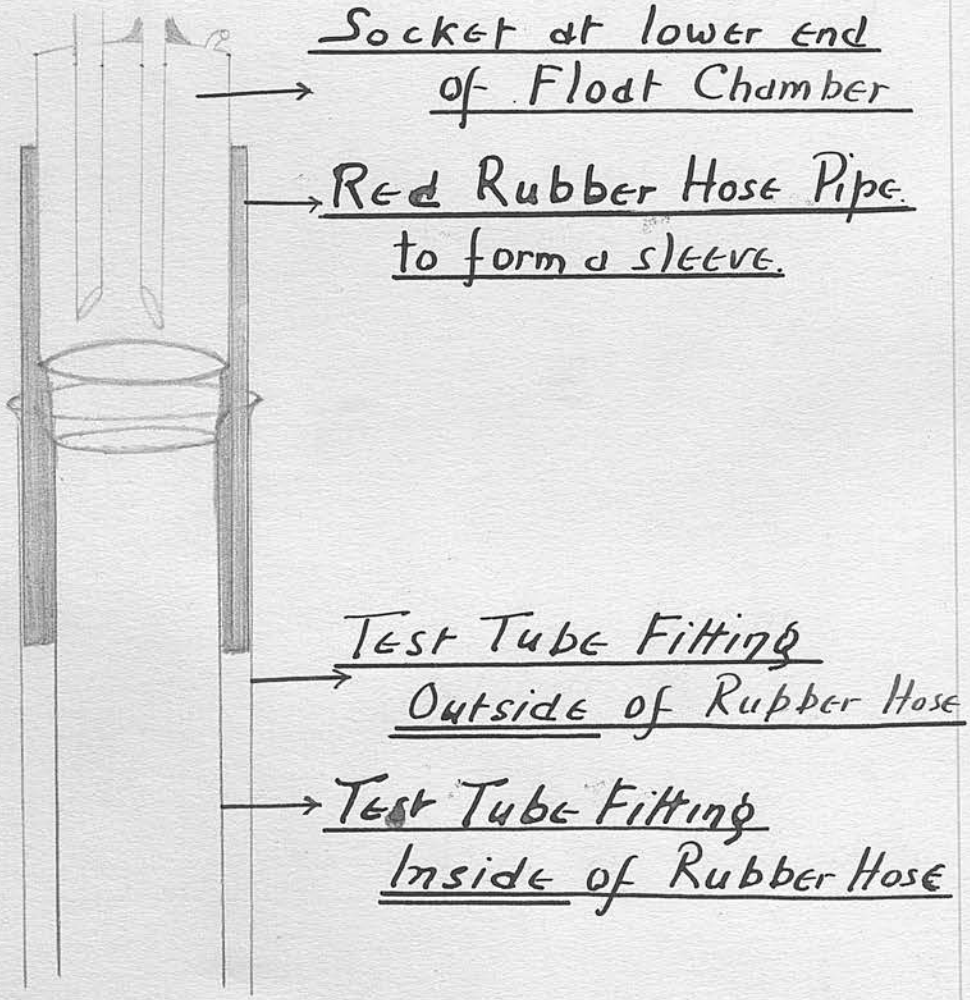
(5) If dust is allowed access to the apparatus so that it can settle on the surface of the copper cylinder, it will prevent the circuit from closing. I found it necessary then to provide a dust excluder. This, in its first form, was conveniently found in the lamb's feeding teat already mentioned in the previous section. They fitted nicely on to the top of the ebonite stopper. They perished readily, how--ever, and I substituted a piece of rubber tubing, the end of which I blocked with an ordinary cork.

(6) /



Suggested Simplification

Note: the discarding of Stopper of the Copper Cylinder and the use of overlapping Copper Strips.



(6) Oxidation of the copper foil may ultimately prevent the low voltage current used from closing the gap in the circuit. Ordinarily this would be over--come by the use of platinum points. In practice, I found that if the copper foil was kept in good cond--dition by cleaning from time to time with a little acetic acid no trouble arose.

(7) Variations of the copper foil strips fixed to the binding posts will readily suggest themselves to many people. The one I found to work most reliably was not the original one used and supplied by the maker, and which I have already described, but that shown in the sketch. It will be readily seen that it suggests a simpler ebonite stopper. One copper strip lies immediately above the other and almost in con--tact with it. The copper cylinder could be dispensed with as would the cavity in which it is contained. This would make for simplicity of construction and simplicity means increased efficiency. This aphorism, applicable to much of our modern civilisation quite apart from mechanical things, is not always appreciat--ed.

(8) Scrupulous cleanliness is essential and it is /

is necessary that the nurse should immediately attend to the apparatus when the bell rings, thus giving uric acid the least possible time to sediment in the float chamber and stop-cock aperture. The apparatus should be cleaned frequently by flushing with distill--ed water.

(9) It is wise to incorporate a light circuit in the apparatus as well as a bell circuit. Thus, if two or three apparatuses are in use at the same time in the same nursery, a nurse can see at once by day or by night which one is in need of attention.

(10) The most useful collecting vessel is a test tube. It is fitted as follows:-

(a) A piece of rubber tubing or hose is selected of a size which will accommodate in its internal diameter the standard fitting cone at the base of the float chamber.

(b) Two sizes of test tube may now be used according to the amount of urine one expects to collect; one of a size which will fit the outside of the rubber hose and one which will fit the inside.

(c) A strip of paper is gummed vertically along the test tube.

(d) /

(d) A small quantity of toluol is introduced into the test tube.

(e) The tube is fixed on to the rubber hose.

(f) The level of the toluol is marked by pencil or pen on the vertical strip of paper.

(g) At each voiding when nurse attends to the apparatus she marks on the vertical strip of paper the new level reached by the toluol and also notes the time.

(h) Great care must be taken that the level of the toluol never becomes so high as to allow it to come in contact with the rubber hose. The latter would then swell up and become in time useless.

(i) If single specimens are wanted, a new test tube with toluol is substituted each time the bell rings, the removed one being put on ice until collected for analysis.

SUMMARY.

(1) A description is given of the evolution of a new and highly reliable signalling device.

(2) Its construction is described.

(3) The technique required to produce the best results is given in detail.

S E C T I O N . IV.

APPARATUS INTENDED FOR SIGNALLING

WHEN AN INFANT VOIDS URINE.

AN HISTORICAL SURVEY.

INTRODUCTION.

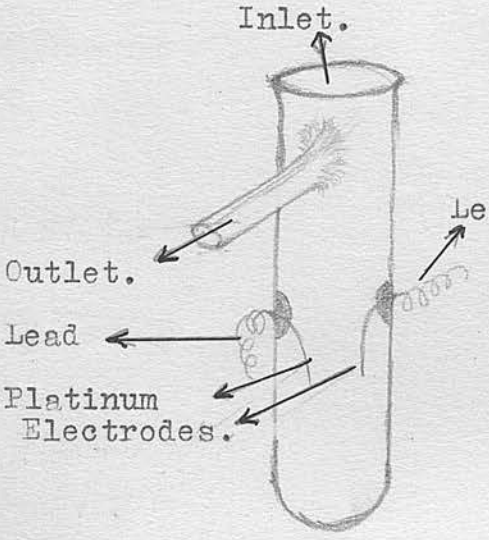
The determining of the frequency with which an infant passes urine is not something new. The early investigators, Martin and Ruge, Schiff, Cruse, and others, depended entirely for their information upon visual observations. Obviously this is not a very satisfactory method, for the observor could never be sure whether one or more voidings had taken place be-:tween the times of observing his urinal. In fact, in Part 11 of this thesis the inaccuracy of the publish-:ed results of Martin and Ruge will be shown.

SURVEY OF LITERATURE.

Nevertheless, until 1914 visual observation was the sole method used. In that year Engel (1914) devised an electrical signalling device which he used in order to determine the frequency with which an in-:fant passed urine. He did not work with new born in-:fants.

He gives no sketch of his apparatus, but a verbal description. How he got the urine from the infant to the apparatus is not quite clear to me. The sketch however, gives some idea of the nature of his signall-:ing method. He speaks of a small /

ENGEL'S APPARATUS.



Drawn from reading his description.

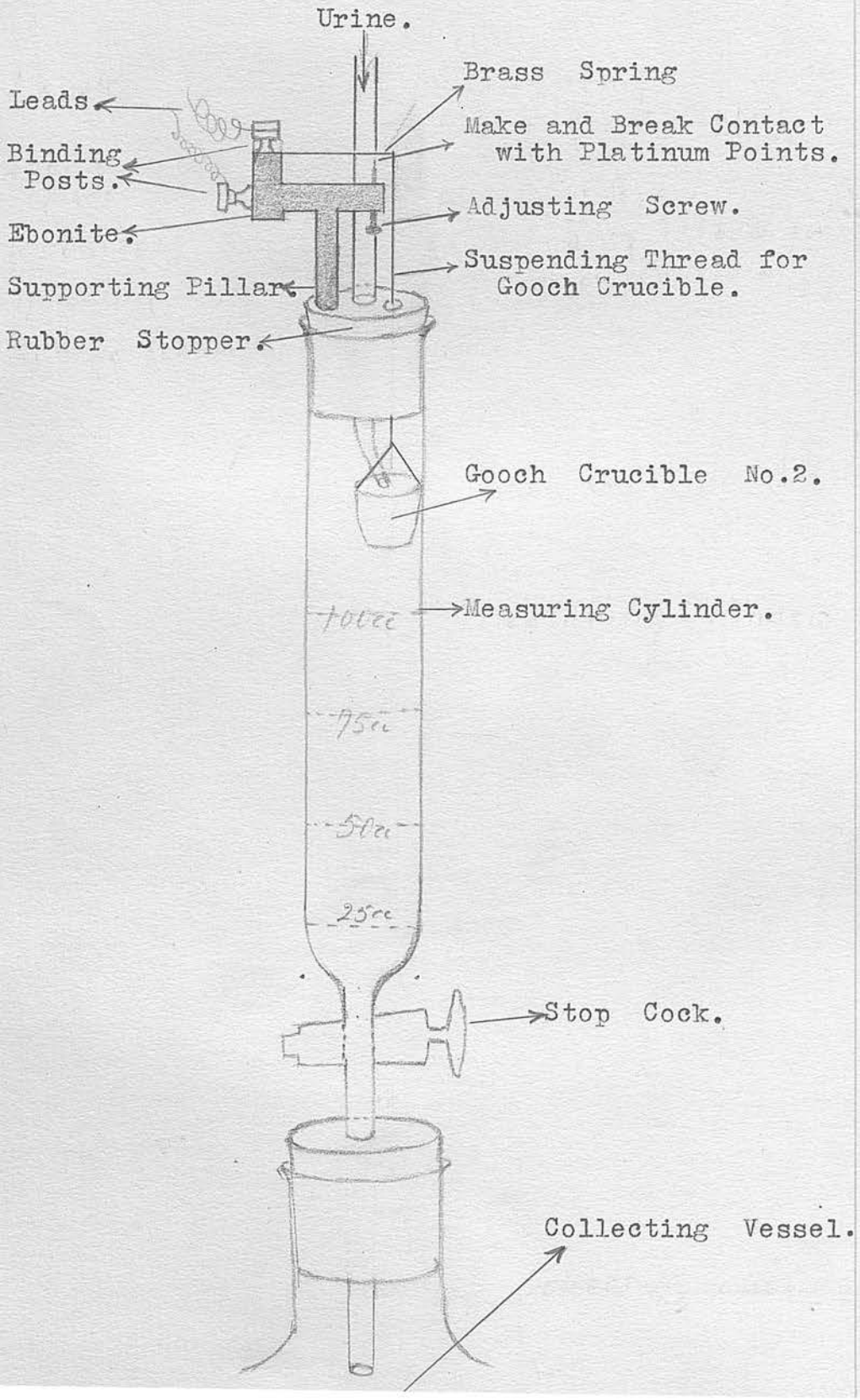
Capacity of tube about 10 ccs.

small receptacle of about 10 cc. capacity, into which were placed two broad platinum electrodes. These he describes as being fused in: "eingeschmolzen", but fused into which particular part of his apparatus is not quite clear, - presumably it is into the side wall of the receptacle. In the upper part of this receptacle near its upper margin or edge there is an overflow tube "seitliches Abfluss rohr." The electrodes are joined up to an electrical circuit incorporating a bell. By the passage of the urine the apparatus automatically signalled, since the urine flowing into the receptacle formed an electrical contact between the electrodes. The excess urine went straight by the overflow tube to a large recept--acle previously placed there for the purpose. As soon as the bell rang, the sister came and tipped the receptacle over so that all the urine ran into the other container and the bell was silent again, - "die Klingel wieder ausgeschaltet."

Apart from knowing when urine is passed, this method is of little value for reasons already given in the previous section of this Thesis. The same thing has been done in a crêche in U.S.A. with much simpler apparatus, merely the insertion of two electrical leads placed /

AFTER:-

HOAGG. LYNNE A.
161 West 61st. Street,
New York,
U. S. A.



placed near to each other inside the infant's dry napkin. Thus, when the napkin became wet a signal was given. No attempt was made to collect the urine. Here it might be pointed out that the electrical conductivity of the urine varies with its pH, for the more alkaline the reaction becomes the less and less reliable does the urine become as a conductor of electricity. I can give no reference concerning the work done in the creche as the information I have was gleaned from the daily press, and neither name nor location was given.

In New York, Lynne A. Hoagg (1932) introduced
1932. his apparatus (see sketch). It is ingenious but I have some doubt as to its reliability when dealing with the small quantities of urine passed by new born infants. The urine is delivered into a No. 2 Gooch crucible. What the capacity of this crucible is, is not quite clear for, in this country at any rate, crucibles are not standardised. The following table gives the sizes of crucibles made in this country by the most reputable makers and one may decide for one--self whether to begin numbering from the smallest or the largest size.

Royal /

Royal Doulton.	Diameter	20,	28,	35,	40 mm.	
	Capacity	8,	13,	28,	37 cc.	
Royal Worcester.	Diameter	20,	29,	36,	42 mm.	
	Capacity	8,	10,	25,	35 cc.	
Height x depth mm.		30 x 26			40 x 38	
Ditto Berlin quality	Capacity cc.	10			25 cc.	
Silica Crucible height		30,	34,	38,	40,	42, 45 mm.
Diameter at top		30,	34,	38,	40,	42, 45 mm.
Capacity		10,	15,	20,	25,	30, 35 cc.

The crucible hangs from the end of a brass spring which is in contact with one of the two electric leads. On filling with urine, the crucible pulls the spring down to make contact with an adjusting screw which, in turn, is in contact with the other electrical lead. Thus, the signal is given. It seems to me that there may be these objections to its use:-

(1) In the actual illustration given the Gooch crucible is shown in contact with the inside wall of the glass measuring cylinder. This might retard its fall. /

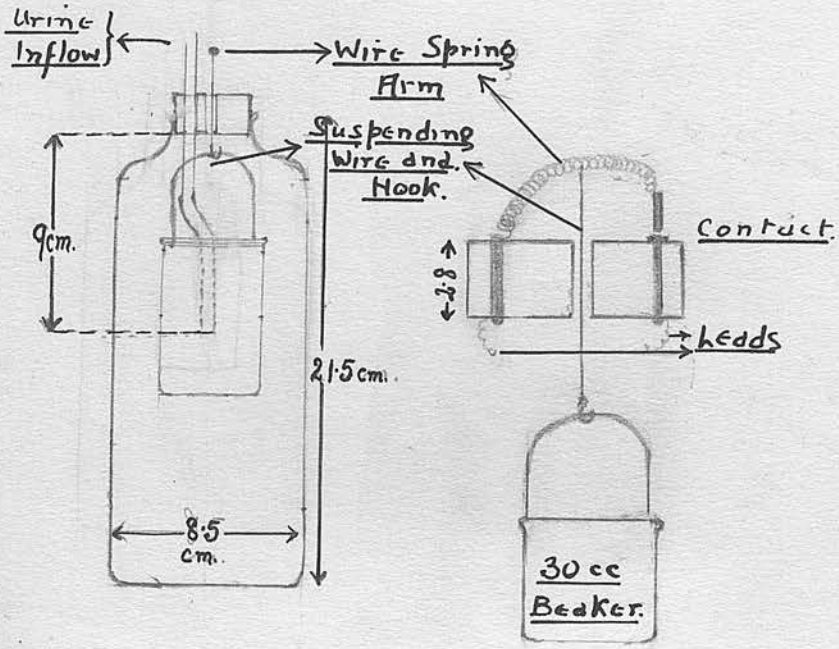
fall.

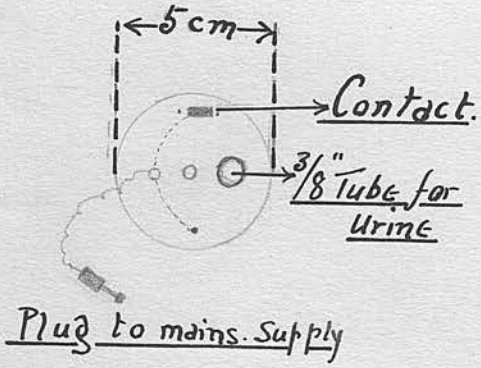
(2) A Gooch crucible has a perforated base so that a fluid put into it runs right through. Hoagg, using paraffin wax, blocks up as many of these perfor--ations as he thinks is necessary in order to retard the escape of the urine and thus give it time to weigh the crucible down. The urine, of course, starts escaping from the moment it enters the crucible and if we have only 2 or 3 cc. to work with, it seems to me highly probable that the bell might never ring; or perhaps give the merest tinkle which would pass un--observed. Hoagg states that it will work with as small a quantity as 3-4 cc. and this, of course, is not sufficiently delicate for new born infants.

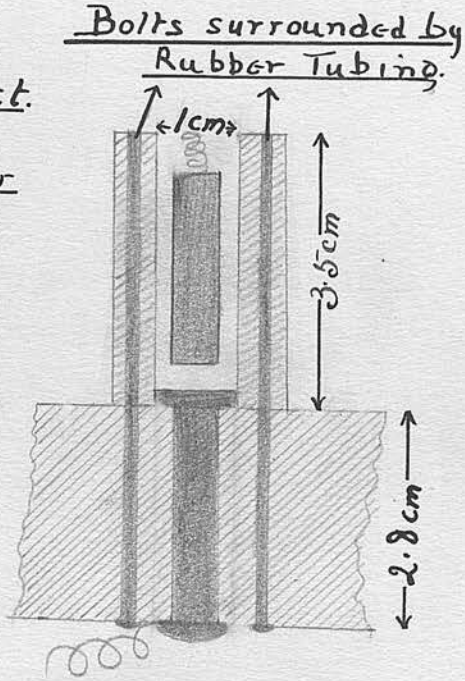
(3) The signal given with this apparatus is momentary, that is, it ceases automatically as soon as the Gooch crucible has sufficiently cleared itself of urine to allow the spring to rise. A momentary signal may pass unnoticed by the nurse.

(4) With urine from new born infants there would undoubtedly be in the first two or three days of life a considerable deposit of uric acid in the crucible. This /

After Lee E Farr
New. York







Detail of Contact.
Actual Size.

This may in some cases be so great that it would block the drainage holes in the crucible base.

(5) As used by Hoagg, the length of tubing which the urine is required to travel is so great that many of the specimens of urine from the new born infant would be almost completely lost in the wetting of the surface to be travelled over.

Also in New York, Farr (1935) describes his apparatus, calling it a urine announcer. It is worked
1935. on the same principle as Hoagg's apparatus, the only essential difference being that the brass spring of the latter is replaced by a coiled spiral spring arm in the former.

I would suggest that there are these objections to Farr's apparatus.

(1) It can only be used for the collection of single specimens. This is obvious for there is no means of emptying the 30 cc. beaker unless it is removed from the apparatus.

(2) There are no means shown for fine adjustment of the coiled wire spring arm so that, presumably, this is done at random by hand. That being so, I find great difficulty in believing Farr's assertion that the apparatus /

apparatus will work with 2-3 cc. of urine.

(3) The fact that he encloses his beaker inside a large bottle, the purpose of which he says is to catch the "urine which escapes from the collecting cup" suggests that he did not work with small quantities of urine. He tells me in a personal communication that the youngest infant he has worked with was 15 months old.

(4) I have a good deal of doubt as to the degree of reliability with which the wire spring arm contact is guided down to make contact with the terminal beneath. Provision is made for guiding it on two sides only (see sketch).

(5) It is quite likely that the wire from which the beaker is suspended would frequently come in contact with the sides of the hole in the large stopper through which it passes. This probably would not matter much in dealing with 20-30 cc. of urine, though Farr states "this system must be so arranged that the beaker swings freely." It certainly would act as a retarding influence with the very small quantities of urine one works with in the new born.

Farr's apparatus has one big advantage over that of /

of Hoagg's, namely, the bell will ring once it has started until the urine is removed. There is no chance of it being overlooked. While Farr does not as yet seem to have published any work in the carrying out of which he has used this apparatus and one must, therefore, suspend judgement, one's confidence is not gained by the drawings with which he illustrates the construction of his apparatus. The drawings given herewith are made from them and they show:-

(a) While the size of the rubber stopper is given as circular, diameter 5 cm. and thickness 2.8 cm., the drawing showing the spring contact arm suggests a stopper of a diameter of almost 8 cm. instead of 5.

(b) The same drawing shows a beaker 5.6 cm. in its greatest width.

(c) While we are told that "the diameter of the beaker is sufficiently less than that of the mouth of the bottle to allow free withdrawal of the beaker when full," yet,

In the drawing showing the beaker inside the bottle one observes a beaker 4.9 cm. in its greatest width inside a bottle, the entrance to which is only 3.5 cm. wide. How the 5 cm. stopper gets in, let alone /

alone that which appears to be nearly 8 cm. in diameter, must be left to a vivid imagination.

One would not cavil at the lack of proper pro-:portion shown in these drawings - for they illustrate perfectly well the method by which the writer intends the apparatus to work - were it not for the fact that he gives measurements in cms. to one decimal place in the instances shown and leaves the rest to imagination.

COMMENTARY.

A careful search of the literature has shown that so far there are only three different apparatuses which have been evolved for the purpose of giving a signal at the moment when the infant passes urine.

The method of Engel is the earliest of these, and it may be said to be simple in construction and infallible in operation. It is none the less an un-:desirable method, since it involves the passage of an electrical current through the urine, thereby altering its chemical and physical characteristics in some de-:gree. As a practical proposition for research work, it may, then, be dismissed.

The other two methods, those of Hoagg and Farr, have been described. The principle employed in their/

their construction is the same in each case. It is to be expected that a good deal of local publicity at least would have been given to Hoagg's invention since it was something very new. Farr, however, does not mention it in his paper. This seems to me strange since both Hoagg and Farr worked in New York, Farr publishing his paper, giving details of his apparatus three years after Hoagg. One presumes, then, that Hoagg's apparatus had either not proved to be too successful or else, as I feel more likely, not sufficiently advertised and so forgotten about in less than three years. This I feel is unfortunate, for, of the two, Hoagg's apparatus gives one a feeling of confidence. It looks better, it is neater in its workmanship, and it does not suggest a Heath Robinson effort, something primitive, imperfect and immature.

Farr's apparatus does not in any way resemble that published in the previous section of this paper. The use by Hoagg of a stop-cock and measuring cylinder gives a sort of superficial resemblance to my own apparatus, but it is no more than a superficial resemblance, for the principle employed "buoyancy" is the reverse of that used by Hoagg, namely, "gravitat-

-ional /

"gravitational pull". Moreover, my own apparatus is much more delicate in its action than Hoagg's or Farr's as judged by their own claims, since it operates with a volume of less than 2 ccs., namely 1.5 ccs., and could I think, be made to work on even half this volume if it were constructed with a smaller float chamber and used a correspondingly smaller sized float.

SUMMARY.

(1). A historical survey is given of the liter-:ature relating to the use of alectrical devises for the purpose of giving a signal when an infant passes urine.

(2). Only three apparatuses have been invented and all are described.

(3). The objections which might be raised against their use, especially in the new born infant, are enumerated.

(4). The difference in their construction and their sensitivity to small quantities of urine is con-:trasted with that of the apparatus described in the previous section.

REFERENCES. /

REFERENCES.

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